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Price Elasticity of Nonresidential Demand for Energy in South Eastern Europe

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Abstract

Recent volatility in international energy prices has revealed South Eastern Europe as one of the most vulnerable regions to such external shocks. Under the current global economic downturn, in addition, the region's energy-intensive industries are faced with the challenge of the weakening demand for their outputs. This paper casts light on the relationship between the price and the demand for energy. Based on firm level data, it is shown that the price elasticity of industrial energy demand is about –0.4 on average. There are a number of data issues to interpret the results correctly. But Albania and Macedonia are systematically found to have a relatively elastic demand for energy on the order of –0.7 to –0.8. In these countries, therefore, price adjustments would be one of the effective policy options to balance demand with supply during the period of energy crisis. In other countries, the demand response would be much weaker; pricing cannot be the only solution. Other policy measures, such as facilitation of firm energy efficiency and improvements in the quality of infrastructure services, may be required.

This paper—a product of the Finance, Economics and Urban Development Department, Sustainable Development Network—is part of a larger effort in the department to examine infrastructure demand in developing and transition countries, particularly focusing on price elasticity of nonresidential energy demand. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at aiimi@worldbank.org.

PRICE ELASTICITY OF NONRESIDENTIAL DEMAND FOR ENERGY IN SOUTH EASTERN EUROPE

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I. Introduction

The world economy experienced several significant hikes in international energy prices since 2000 until recently. The crude oil price of West Texas Intermediate (WTI) exceeded 100 U.S. dollars per barrel in February 2008. The wholesale electricity price (Phelix Day Base) at the European Energy Exchange also reached 100 euros per MWh in April 2008. A series of increases in energy prices revealed that South Eastern Europe (SEE) is one of the vulnerable regions to such external energy shocks. The recent suspension of international natural gas delivery from Russia caused mass power outages and mass heating failures in the Balkan states, such as Bulgaria and Macedonia. Hydro-dependent countries, such as Albania, will experience large-scale of load shedding if severe droughts happen.

More recently, the region seems to be faced with another emerging challenge to adjust production in energy-intensive industries, such as cement, metal, paper and chemical manufacturing, which have been affected negatively by the sharp economic slowdown since 2008. Two conflicting effects are predicted under the global economic crisis. Given the weakening demand for their products, on one hand, the industrial and commercial demand for energy would decrease. On the other hand, the demand may increase because of the decline in international energy prices.

The current paper attempts to explore the possibility to infer the demand behavior of industrial energy users from the existing micro-data, Business Environment and Enterprise Performance Surveys. Because of various data limitations, the estimation results should be interpreted with caution, especially when drawing specific policy implications. This paper will focus on estimating the relationship between the prices and the demand using the micro-level data in seven SEE countries: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Macedonia, Romania, and Serbia. It also casts light on the demand respond to shocks in the real economy. The paper focuses on the industrial or nonresidential demand for energy, because of its potential importance in setting the development strategy in the energy sector, including pricing issues.[1] The estimated demand-price relationship can show how energy consumers, especially large-volume users, would respond to an external supply shock. What would happen if such a shock is transferred to energy end-users? Given some historical and institutional background in each country's electricity sector, the paper discusses what policy option can be considered reliable to accommodate expected price changes. Based on the estimation results, the paper also casts light on how inefficient firms would be. The estimated technical (in)efficiency seems to vary significantly among countries even within the region.

Under the Energy Community framework established in 2005,[2] the region has been working on various structural and economic issues in the energy sector. It generally aims at creating a stable regulatory and market structure to attract more investment, facilitate regional energy trade, and whence enhance security of energy supply in the region. The progress varies across member countries (e.g., IEA, 2008; EC, 2009). Despite the structural and market reforms, such as unbundling and private sector participation, inefficient pricing, unreliable supply, energy inefficiency in housing and appliances, and environmental concerns are considered among the most important challenges in the region.

In this regard, the importance of understanding the demand for energy cannot be overemphasized. Note that it is not always easy to estimate with available data and there are a number of data and econometric issues that need to be taken into account. When designing and implementing any upward and downward price and/or supply adjustments, the price-demand relationship, which is by and large represented by price elasticities, is most essential, though the current paper also addresses other issues, such as demand response to real shocks. The textbook theory of supply and demand tells us that when the supply condition of energy

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[1] From the data point of view, the current paper analyzes the demand for "energy," including electricity and other fuels, because the used data cover both of them. However, many parts of the discussion will interpret the estimation results as electricity, because it is the major energy source in the SEE region. Still, note that this is merely an approximation and it is in fact one of the possible distortionary factors if our estimation results would be found counterintuitive in the region's electricity sector. This does not mean that other energy sources are not important. In some Eastern Europe countries, such as Croatia and Romania, natural gas contributes to more than 25 percent of total primary energy supply (e.g., IEA, 2008).

[2] It entered into force in July 2006.

changes for some exogenous reason, such as a sudden global tightness in oil or electricity and an unexpected shutdown of domestic power plants, the equilibrium would behave differently depending on price elasticity of demand. If the demand is elastic, a small change on the supply side would result in large adjustments in energy consumption. By contrast, if demand is relatively price-inelastic, there is little room for consumption to accommodate a given supply-side change. Instead, prices must be of necessity adjusted to a large extent. This is the basic reason why the Ramsey pricing calls for lower margins (or prices) for more elastic demanders in the price discrimination context.

According to the traditional literature review, the price elasticity of "electricity" demand is estimated from –1.02 to –2.00 for residential users and from –1.25 to –1.94 for industrial consumers (Taylor, 1975). More recently, a meta-analysis by Espey and Espey (2004) shows that the average residential electricity price elasticity among earlier studies published between 1971 and 2000 is –0.35 in the short run and –0.85 over the long run. Bernstein and Griffin (2005), using U.S. state-level data, find that the residential electricity elasticities are –0.24 and –0.32 in the short and long run, respectively. For commercial users, the short- and long-run price elasticities are estimated at –0.21 and –0.97, respectively. Noticeably, another recent work, which relies on the same U.S. data for a similar period of time but at the national aggregate level, indicates that the industrial demand elasticity may be rather smaller in absolute terms than other previous works (Kamerschen and Porter, 2004). It is shown that the residential electricity elasticity ranges between –0.85 and –0.94, while the industrial one varies from –0.34 to –0.55.

As to "energy" demand in general, the price elasticity of manufacturing energy demand is estimated at –0.28 to –0.49 in the United States (Anderson, 1981). As per Pindyck and Rotemberg (1983), the elasticity can be different depending on firms' dynamic investment behavior; the estimated elasticity of U.S. manufacturing is –0.36 in the short run, –0.58 in the medium run, and –0.99 in the long run. It is also shown that energy demand elasticities are different across industries (Denny *et al*., 1981). The short-run elasticity varies from –0.61 in the paper industry to nearly zero in the tobacco, metal fabricating, and machinery electrical industries. The long-run energy elasticities are also different between industries, ranging between –0.01 to –0.73.

The existing literature reveals two facts. First, industrial energy or electricity consumers tend to have greater price elasticity (in absolute terms) than residents. This is because households have few energy alternatives regardless of prices. They must use energy for their living. On the other hand, industrial energy users, such as manufacturers and hotels, can choose technology and save energy by introducing energy-efficient devices and machines if energy prices go up (i.e., energy-capital substation).[3] Therefore, the industrial price elasticity is normally higher over the medium to long run. From the policy point of view, this means that enterprises would be more responsive to the government pricing policy and the supply-side changes. Note that energy prices are still regulated in many countries. In addition, nonresidential demand usually accounts for 40–60 percent of total demand for energy in the SEE region.[4] Hence, in order to design the optimal pricing structure and govern energy demand and supply, the nonresidential demand cannot be underestimated.

Second, in the literature, the estimated elasticities have a wide variation and seem to be difficult to compare with one another. Of course, the analyzed data are different and the estimation methods are also different. However, particularly for industrial demand, it seems difficult to find consistent evidence on price elasticities, as pointed out by Bohi and Zimmerman (1984). The range of estimates is too wide to agree on the norm. The wide variation is interpreted as a potential risk of over-generalizing our results, and it also means that industrial energy demand would be highly country- and location-specific and dependent on the system of production and technology in the economy. By contrast, it is fairly

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[3] Norsworthy and Harper (1981) show that the capital-energy elasticity of substitution is found largely positive in the U.S. manufacturing sector. The estimated complementarity can be understood to mean that the technology embodied in equipment is designed to consume, rather than save, energy. This is typically true in the U.S. history, because capital was introduced mainly for labor-saving purposes, rather than energy-saving.

[4] The analysis focuses on the industrial demand for energy and ignores the residential side, such as willingness-to-pay analysis. If there is any information on the residential demand, needless to say, it should be incorporated into the policy consideration. It would expand available options to policymakers.

reasonable to assume that residential energy demand would be more or less the same in a certain region.

The current paper concentrates on investigating the industrial demand for energy, partially because of data availability but mostly because it is expected to yield important policy implications for the SEE countries, where the supply of energy is not always secured and several energy-intensive industries agglomerate in the region to take advantage of cheaper energy inputs. The paper mainly uses firm-level data from the 2005 Business Environment and Enterprise Performance Survey (BEEPS) and estimates the price elasticities of industrial energy demand.[5] Unlike some of the earlier literature (e.g., Kamerschen and Porter, 2004; Filippini and Hunt, 2009), the analysis focuses on investigating how individual enterprises would likely respond to any possible supply shock of energy. The firm behavior may differ across countries, from sector to sector and depending on individual firms. The paper also quantifies technical inefficiency in firm production by applying a stochastic frontier technique.

The remainder of the paper is organized as follows: Section II discusses the importance of the price elasticity for energy in the real economy. Section III provides a brief overview of energy demand and supply in SEE countries. Section IV establishes an empirical model and describes our data uses. Section V summarizes the main estimation results, and Section VI discusses some policy implications.

II. Price Elasticity for Energy and Its Policy Implications

When implementing industrial and energy policies, policymakers should pay more attention to the industrial energy demand. There are two particularly important parameters when

[5] The 2005 BEEPS data originally cover about 4,000 firms in 26 ECA countries (e.g., World Bank, 2007a). But the current paper relies on data for only seven SEE states.

analyzing demand side issues: (i) price elasticity of energy demand and (ii) conditional factor demand elasticity with respect to output.

First, suppose that the capacity to supply energy is not sufficient enough to meet the potential demand, as in Albania and Macedonia. Then, any external adverse shock will easily translate into a considerable shift of the supply curve upward. With a highly elastic demand, for instance, greater than 0.5 in absolute terms, the domestic energy price can be kept at a reasonable level, because the shock would be absorbed largely by quantity adjustments. A 10 percent increase in energy tariffs would reduce energy consumption by more than 5 percent. If energy demand is inelastic, for instance, less than 0.1 in absolute term, the economy will have to experience a sizable adjustment in energy prices. These are movements along the demand curve, as illustrated in Figure 1.[6]

It is a political decision whether or not to pass the high energy prices realized at the new equilibrium on to end-users. A significant increase in retail energy prices may not be acceptable for industrial and commercial users, let alone for residential customers (affordability issue).[7] In theory, the Ramsey pricing rule suggests that if governments (or operators) can discriminate energy prices among different customers, they should charge more to less elastic customers in order to maximize economic efficiency, because their demand is less likely to react to high tariffs. For price sensitive consumers, prices must be kept lower; otherwise, these consumers would reduce their consumption. Note that there is no consideration of equity or other economic factors, such as competitiveness, in the Ramsey

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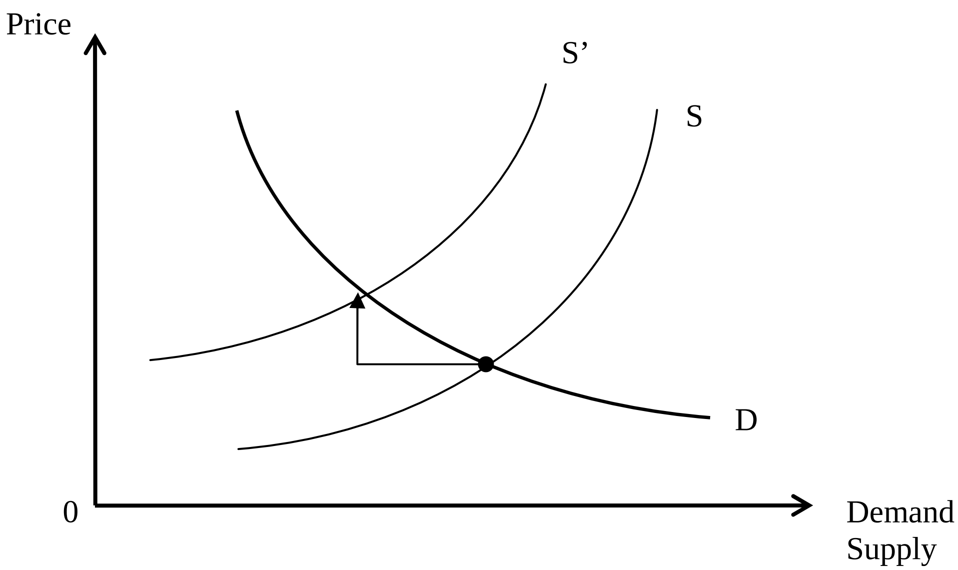
[6] The figure is illustrative and may not depict the real situation. Particularly, the supply curve can vary depending on the supply structure of each country. It could be much steep but may be a vertical line because there are some elements that follow the market mechanisms in the international energy markets. In addition, although a certain pressure is surely created, the suggested movement may not necessarily take place because the domestic market is usually regulated.

[7] In the Europe and Central Asia (ECA) Region, a normal affordability ratio for the power sector may be 10 to 15 percent of total household spending in case electricity is used for heating, cooking and hot water. If other fuels are used for these purposes, a threshold may be 10 percent (World Bank, 2006a).

rule. As already discussed in the economic literature,[8] the Ramsey pricing may not be compatible with the equity objective and may run the risk of reducing firm competitiveness and thereby economic growth.

Figure 1. Price elasticity of energy demand and energy supply shocks



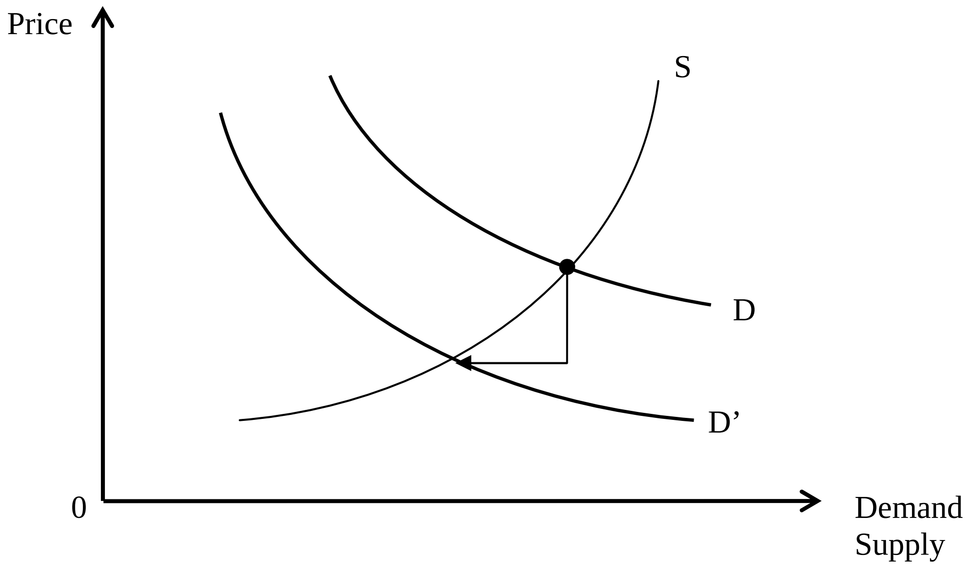
Source: Author's illustration.

Second, energy demand must of necessity depend on production levels. As experienced during the oil crisis of the 1970s, the decline in energy consumption would inevitably occur in response to stagnation in production, commerce and employment, unless there is sizable technical inefficiency in the economic system (e.g., Bohi and Powers, 1993).[9] This is a shift of the demand function (Figure 2). How much it would shift is dependent on demand parameters.

[8] In general, there are two problems caused by price discrimination when a monopolist sets higher prices to inelastic customers. First, price discrimination may worsen the distribution of income even if it improves economic efficiency. Second, it may reduce efficiency if the risks of compounded output reducing effects are large (see, for example, Schmalensee (1981) and Sheehan (1991)).

[9] In fact, one may expect that there would be a mass of technical inefficiency in transition economies, particularly in terms of energy use. The following empirical analysis will take this possibility into account.

Figure 2. Energy demand shift conditional on output demand shocks



Source: Author's illustration.

If a new equilibrium price caused by some of these exogenous shocks is not allowed to take place for some reason, both direct and indirect costs would be imposed on the economy. First, if the price of retail energy is kept lower than the sustainable supply cost, governments need to subsidize the sector and fill in the gap between the retail and production prices either through direct subsidy to utilities or by hiding such costs somewhere off the budget. This is a direct cost of underpricing, which is one of the important factors of quasi-fiscal deficits in the public energy provision.[10] In either case, the lack of financial viability would threaten the sustainability of infrastructure development sooner or later. In some countries of the Europe and Central Asia (ECA) region, the quasi-fiscal deficit in the electricity sector is estimated to reach more than 10 percent of GDP (Table 1). In our sample, it was about 0.9 percent for Croatia, while it was estimated to exceed 4 percent of GDP for Albania, Bulgaria and Serbia and Montenegro in 2003 (World Bank, 2006b).

[10] The other two factors of quasi-fiscal deficits are associated with excessive technical losses and commercial losses.

Table 1. Quasi-fiscal deficits in electricity sector (% of GDP)

	2000	2001	2002	2003
Albania	**10.5**	**7.4**	**6.1**	**4.2**
Armenia	1.4	2.2	1.0	1.0
Azerbaijan	11.4	10.1	8.1	6.4
Belarus	2.5	2.2	0.8	0.0
Bosnia	**5.4**	**5.1**	**3.9**	**1.4**
Bulgaria	**9.5**	**8.1**	**7.0**	**3.8**
Croatia	**2.1**	**2.1**	**1.8**	**0.9**
Georgia	12.2	6.9	6.5	6.0
Kazakhstan	3.3	2.9	2.4	1.3
Kyrgyz Rep.	18.6	25.2	19.0	9.2
Macedonia	**5.0**	**3.6**	**3.5**	**5.6**
Moldova	10.8	7.7	3.2	2.7
Poland	0.3	1.4	1.1	0.8
Romania	**3.8**	**3.7**	**2.5**	**1.3**
Russia	5.4	3.6	3.1	1.0
Serbia & Montenegro	**22.5**	**16.5**	**8.9**	**8.7**
Tajikistan	28.2	25.0	23.0	16.5
Turkey	1.8	2.1	1.1	0.6
Ukraine	9.1	6.8	5.6	4.0
Uzbekistan	8.6	10.2	13.1	12.1

Source: World Bank (2006b).

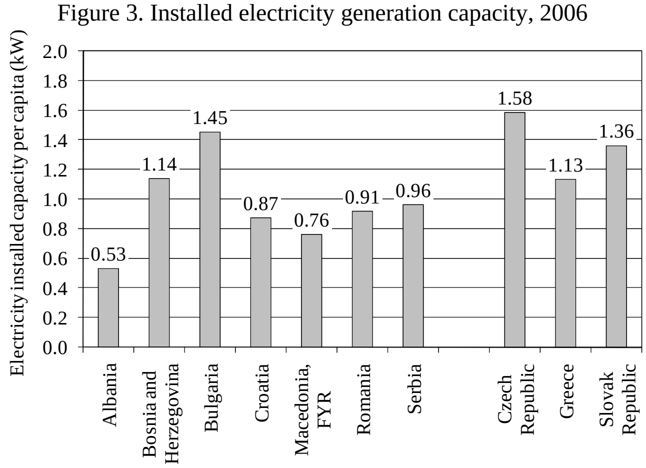
Second, an indirect cost of underpricing is inefficient resource allocation in the economy. Underpricing must of necessity induce users to over-consume energy and act as a disincentive to improving energy efficiency because firms are likely to keep using old equipment and machinery, rather than investing in costly energy efficient technologies. Overconsumption would in turn deteriorate the financial viability problem, making it more difficult to maintain the quality of utility services.

III. An Overview of Energy Supply and Demand in South Eastern Europe

Supply

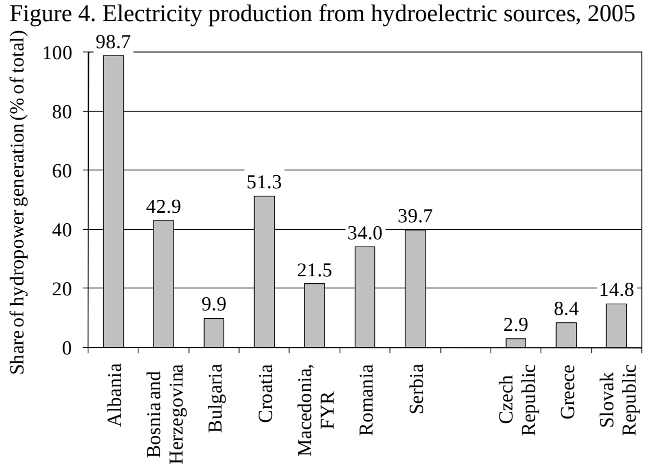
The supply capacity of electricity varies markedly across SEE countries, as partly documented by IEA (2008). In terms of installed capacity per capita, Albania has only one-third as much generation capacity as more advanced countries in Europe (Figure 3). Croatia and Macedonia are also potentially deficient in domestic electricity supply capacity. Apparently, these inadequacies can threaten domestic energy supply and trigger off massive load shedding, when an external energy shock occurs. The vulnerability may increase particularly when countries are largely dependent on hydrology for energy. In Albania, for instance, three hydropower plants account for over 90 percent of domestic electricity production (Figure 4).[11] Consequently, in drought years the country had to import 500 to 2,000 GWh of energy or 10 to 50 percent of total power consumption at unfavorable international prices, with approximately 10 percent of demand still left unmet.

Figure 3. Installed electricity generation capacity, 2006



Source: *World Development Indicators* (WDI), Energy Information Administration database and IPA (2009).

Figure 4. Electricity production from hydroelectric sources, 2005



Sources: *WDI*, Energy Information Administration database and IPA (2009).

Demand

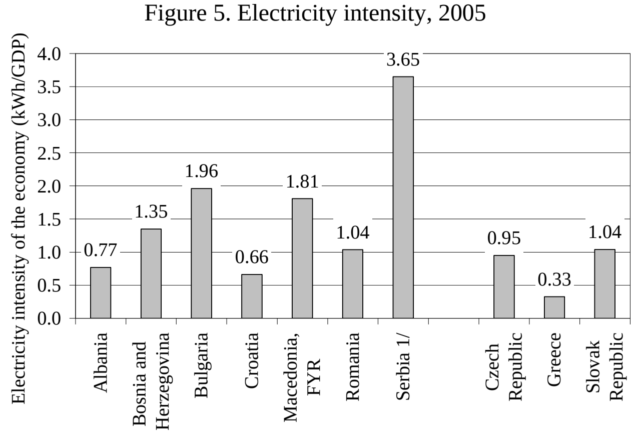
From the industrial demand point of view, Bulgaria, Macedonia and Serbia seem to be energy-intensive economies. In general, energy demand increases proportionally with economic development, but how much energy is required to produce one unit of output—

[11] For instance, see Fida *et al.* (2009).

which is referred to as energy intensity—varies among countries. It depends on the economic and industrial structure. High energy intensity of the economy results from inefficient consumption by not only industries but also households and heating load of the building sector. Serbia is estimated to use three times more electricity than more developed neighboring countries (Figure 5). Bulgaria and Macedonia also seem to be using electricity quite intensively. Croatia is the least energy-intensive economy in the SEE region; only 0.66 kWh is required to produce $1 of GDP. The ECA average (only low- and middle-income countries) is about 2 kWh per GDP.

The observed difference in energy intensity is also partly attributed to the difference in the economy's production and export structure. In particular in the SEE region, several energy-intensive industries are located, such as cement and copper in Albania, steel and zinc- and copper-based metallurgical production in Bulgaria, metal-processing in Macedonia, and aluminum in Montenegro. These industries were often established for political reasons during the Soviet era, and their facilities tend to be out of date and inefficient. Still, they are often playing an important role in production and exports of the economy. Macedonia's non-metal minerals, iron and steel products account for 18 percent of total exports (Figure 6).[12]

Figure 5. Electricity intensity, 2005

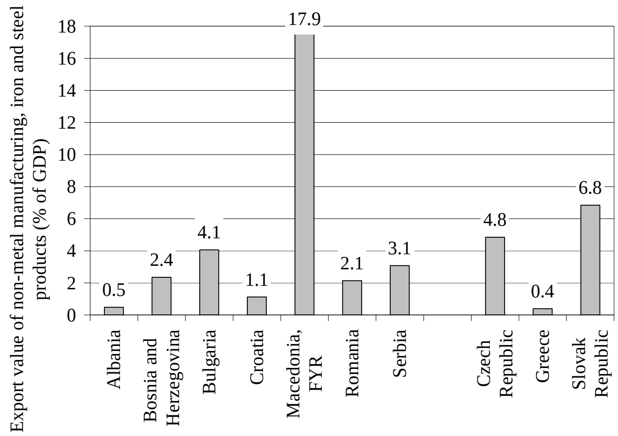


1/ 2003 for Serbia.

Source: Author's calculation based on *WDI* and IAEA *Energy and Environment Data Reference Bank.*

[12] These export items are classified under the SITC Code 66 non-metal mineral, and 67 iron and steel.

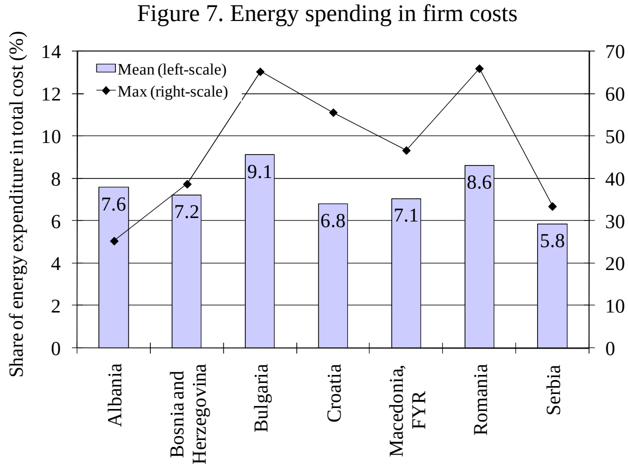
Figure 6. Exports from selected energy-intensive industries, 2007



Source: Author’s calculation based on *WDI* and WITS *COMTRADE Database*.

On the micro level, our enterprise data, in which “energy” covers not only electricity but also other fuel, show that Bulgarian companies are using energy most intensively. There are certain similarities to the above figures, but not completely. The average share of energy spending in total costs is about 9 percent in Bulgaria, which is followed by 8.6 percent of Romania and 7.6 percent of Albania (Figure 7). Of particular note, there is a large variation in energy intensity across firms even in a country. Some companies in Bulgaria are spending more than 60 percent of total costs on energy. They are considered especially energy-intensive enterprises. On the other hand, there are a number of firms that expend less than 10 percent on energy of their total costs. This firm-level heterogeneity is an important fact for designing micro-data analysis like the current paper.

Figure 7. Energy spending in firm costs



Source: Author’s calculation based on BEEP data.

Prices and deficits

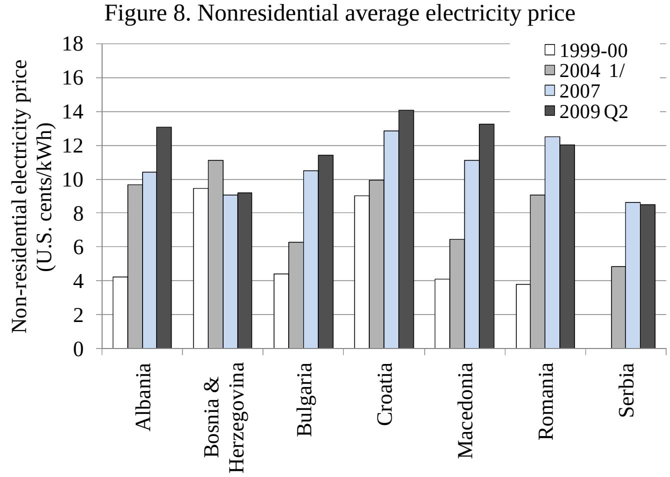
Given the tight supply positions to meet the growing demand, all the SEE countries have rapidly increased electricity tariffs in recent years. Albania and Bulgaria nearly tripled nonresidential electricity prices between 2000 and 2009 (Figure 8). Croatia and Romania have relatively high rates in the region. Macedonia has also adjusted the nonresidential price quickly in recent years. The nonresidential electricity prices exceed 10 U.S. cents per kWh in all SEE countries but Serbia and Bosnia and Herzegovina. This level of price is almost equivalent to or even higher than the world-highest "industrial" electricity prices in OECD countries, such as Ireland, the United Kingdom and the U.S. states of New York and California.[13]

Compared with residential tariffs, many countries have proceeded with rebalancing between residential and industrial electricity prices, in favor of nonresidential customers. The relative nonresidential price to residential tariff declined from 1.2–1.6 to nearly or less than one (Figure 9). Romania is keeping nonresidential tariffs relatively low, compared with those for residential consumers. Particularly, some eligible industrial consumers are enjoying discounted prices. From the utility point of view, in fact, the cost of transmitting electricity to large-volume consumers with a higher voltage could be cheaper than low-voltage power supply. High voltage can reduce transmission losses. In addition, the cost of electrical transformers may not be required, because large-volume users may use high-voltage energy as it is. Otherwise, they may be equipped with private transformers in their factories or buildings. In Macedonia, the relative nonresidential price increased substantially, but the general level of electricity prices may remain relatively low for both residential and nonresidential customers.

[13] According to IEA database, the average industrial electricity price in OECD member countries in Europe was estimated at 11.6 U.S. cents per kWh in 2007, which was twice as high as the average in 2002, i.e., 5.9 cents.

The main reason the countries have increasingly adjusted their domestic prices is that electricity production costs increased significantly due to high international commodity prices of coal, oil and natural gas and soaring import prices of electricity. One of the major energy markets in Europe, European Energy Exchange (EEX) in Germany, has exhibited considerable increases in electricity prices since 2000 (Figure 10). The average baseload spot price exceeded 60 euros in 2006, and after some fluctuation, reached 70 euros in 2008. The Balkan states have to pay some additional transmission fees to this, which varies from several to 15 euros reflecting the available transmission capacity and its market prices.[14]

Figure 8. Nonresidential average electricity price

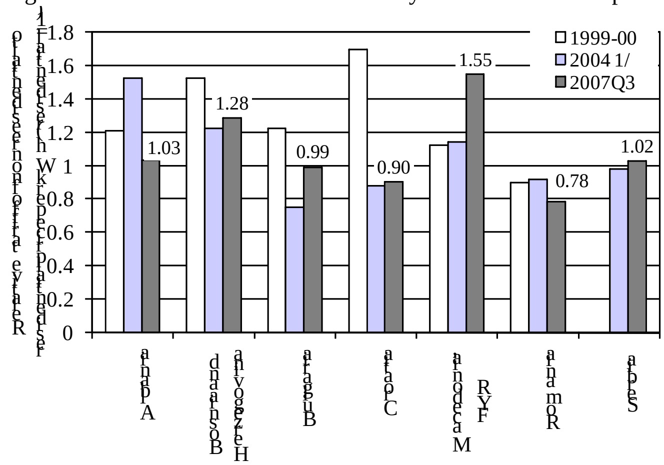


1/ 2006 for Serbia.

Source: ERRA database.

[14] For instance, because of the transmission bottleneck between Albania and Montenegro, the transmission capacity right between Podgorica and Albania at the Montenegrian power system was priced at as high as 8 to 9 euros per MW with a maximum of 15 euros in 2007.

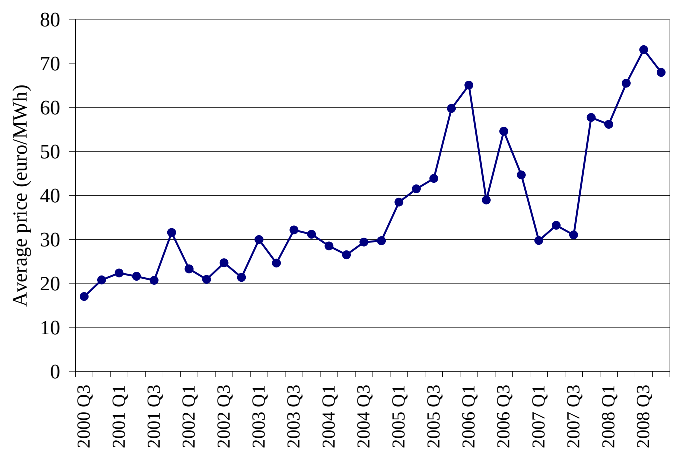
Figure 9. Relative nonresidential electricity tariff to residential price



1/ 2006 for Serbia.

Source: ERRA database.

Figure 10. Average price for baseload power at European Energy Exchange

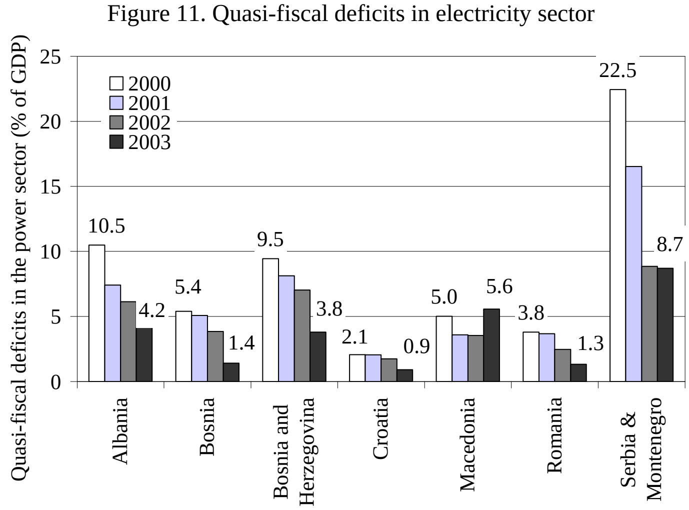


Source: EEX.

Through continued government efforts to rationalize energy prices at the retail level, the deficits of the electricity sector were largely removed in the early 2000s, though not eliminated completely (Figure 11). Although no comparable estimates are available after 2003, some countries seem to have continued passing high international energy prices to end users to a certain extent, meaning that the quasi-fiscal deficits might have declined further. As shown in Figure 8, Bulgaria and Macedonia increased electricity prices aggressively since around 2004. However, these may be a partial translation. Recall that the market electricity price at the EEX doubled during the past three years.[15] Albania is modestly adjusting domestic electricity prices in recent years, though the existing price may already be high with the country's income level taken into account.

The implemented price adjustments seem to have successfully motivated consumers to use electricity more wisely than before, but perhaps the response may not be sufficient. Per capita consumption of electricity in SEE countries continues increasing and remains at high levels by global standards (Figure 12). The figure does not mean that there was no effect of price adjustments; rather, it implies that the demand for energy or electricity may continue to be strong in this region for other reasons, for instance, the region's relatively robust economic growth (until recently).[16] This reminds us of the difficulty in governing the demand for energy, while balancing various policy objectives, including energy security, economic growth and fiscal consolidation.

Figure 11. Quasi-fiscal deficits in electricity sector

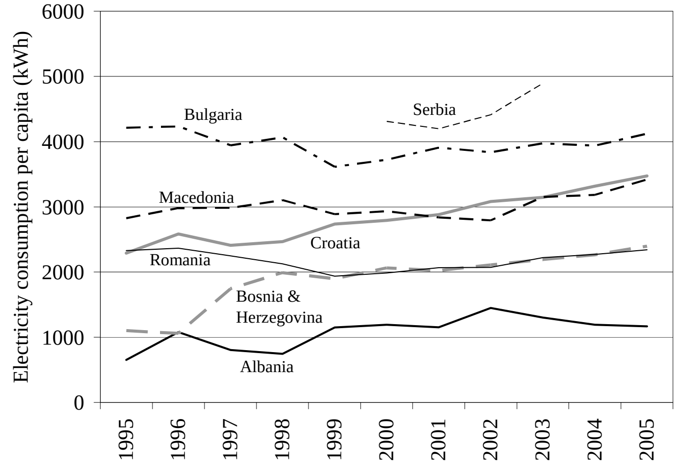


Source: World Bank (2006b).

[15] There is normally a time lag between an increase in market prices and the associated administered price adjustment. Moreover, high international energy prices should only partially translate into domestic retail prices, when some fraction of the domestic energy is purchased from abroad.

[16] In addition, this figure includes the residential demand for electricity, which is considered less price-elastic and expected to increase along with economic development.

Figure 12. Electricity consumption per capita



Source: Author's calculation based on *WDI* and IAEA *Energy and Environment Data Reference Bank*.

Quality of services

Finally, one remaining important characteristic of the SEE countries is the poor quality of public electricity services. This will complicate the sector's financial problem, as in many other transition economies. While tariff adjustments are difficult to justify in the absence of reliable power supply, the quality of services cannot be improved without tariff increases. It is worth noting that unlike residential customers, industrial energy users can always choose to install their own captive generators if they are not satisfied with the quality and price of publicly provided energy. In the SEE region, in fact, several large-volume energy consumers, such as a new cement factory in Albania, do not rely on public utilities for energy.

From the empirical perspective, it is generally difficult to measure the quality of public infrastructure. The BEEPS asks individual firms various questions about the quality of infrastructure, such as annual frequency and daily duration of service suspensions. Hence, the information is available on how many days a firm experienced power outages last year. The answer ranges from zero to 365 days. The information is also available on how many hours are required to restore the electricity supply if it is interrupted. It ranges from zero to 24 hours.

By regional comparison, the ECA countries in general have had relatively good quality of infrastructure services, similar to the East Asia and Pacific region. The simple average frequency of electricity outages in ECA was less than 10 days per year in 2004. However, this does not mean that all the countries in the ECA region would have overcome the quality problems in utility services. First, some enterprises in the region may continue suffering from long-lasting service interruptions. The average duration required for electricity service recovery is estimated at 5.3 hours in ECA.

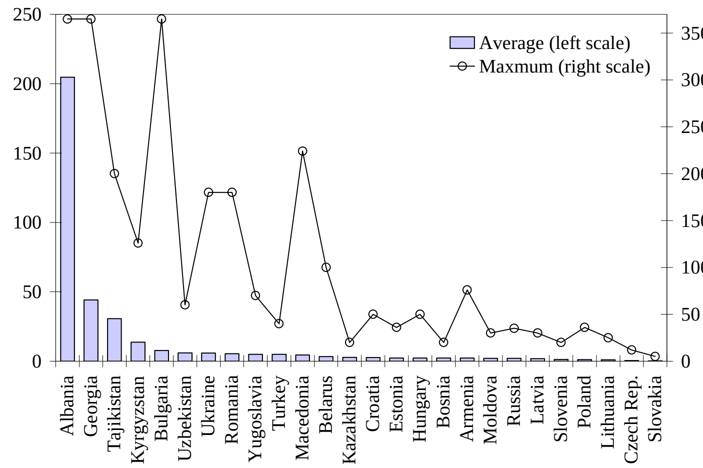
Second, there are wide variations in infrastructure quality among ECA countries (Figure 13). Albania has the poorest quality of electricity infrastructure services; the number of days without sufficient electricity exceeded 200 days.[17] It is followed by Bulgaria, Romania, and Serbia and Montenegro in the SEE region.

Third, it is noticeable that not all enterprises in Albania are equally suffering infrastructure difficulties, and that there are also a number of firms operating under harsh infrastructure conditions in other countries. Some firms in Bulgaria experienced continuous power outages every day.[18] Several companies in Macedonia also claimed that electricity interruptions occurred more than 200 days a year, which is at the same frequency as in Albania. Importantly, the quality of utility services is also changing over time. When compared the 2002 and 2005 BEEPS results, most countries, except Albania, succeeded in improving the quality of utility services. For instance, Azerbaijan achieved the most spectacular improvement in this area for recent years; by investing a lot of public resources in power stations, the country succeeded in restoring a nearly 24-hour electricity supply.

[17] One might consider Albania to be an outlier, possibly creating statistical noise in data, when pooling its observations. The following empirical analysis will account for this fact and show that the main estimation results are robust regardless of whether the country is included or not.

[18] Note that in the BEEPS, the infrastructure quality data were collected in the way that the interview had been conducted to firm managers. Therefore, they are not subjective views but may reflect some approximations made by managers. However, all the indications are that in each country there is a significant variation from company to company in the level of infrastructure service quality they received.

Figure 13. Number of days with power outages in Europe and Central Asia



Source: BEEPS 2005.

IV. EMPIRICAL MODELS AND DATA

The following simple cost function is considered: $C = F(W, Y; A)$ where W and Y represent input prices and outputs, respectively. A is a productivity or fixed cost parameter, which is assumed to be affected by the quality of public infrastructure and other unobserved factors.[19] Based on the traditional industrial organization literature (e.g., Nerlove, 1963; Christensen and Greene, 1976; Fuss, 1977), a variant of the translog cost function is examined:

$$\begin{aligned}\ln C = {} & \beta_0 + \beta_Y \ln Y + \frac{1}{2}\beta_{YY}(\ln Y)^2 + \sum_i \beta_{W_i} \ln W_i + \frac{1}{2}\sum_i \sum_j \beta_{W_i W_j} \ln W_i \ln W_j \\ & + \sum_i \beta_{YW_i} \ln Y \ln W_i + \sum_k \beta_{Z_k} Z_k + \frac{1}{2}\sum_k \sum_h \beta_{Z_k Z_h} Z_k Z_h + \sum_k \beta_{YZ_k} Z_k \ln Y \\ & + \sum_i \sum_k \beta_{W_i Z_k} Z_k \ln W_i + \varepsilon\end{aligned} \tag{1}$$

where C denotes the amount of total operating cost, Y is an output proxy, and W_i is the ith input price. Z_k represents the kth measure of infrastructure quality.

[19] This potentially includes a variety of institutional and structural unobservables, which constitute a statistical error in the model.

Three inputs are considered: labor, energy and the rest of the costs. Conceptually, the last can be referred to as capital or equipment. Thus, denote $i, j = \{L, E, K\}$ in Equation (1). Unit labor price W_L is obtained by dividing total wage expenses by the number of employees. Energy price W_E is calculated by dividing energy and fuel expenses by the amount of assets, more precisely total asset replacement costs; there is no information on the actual amounts of electricity and fuel consumption in our data.[20] Finally, "capital" potentially consists of various costs, and the unit price of input capital (W_K) is computed by dividing the operating expenses other than labor and energy costs by the total asset replacement costs.[21]

Output is measured by total sales in U.S. dollars, because no physical output variable that is common across companies is available in the database. Since firms in the sample engage in various businesses, this is only the usable common proxy for outputs. To control for sector heterogeneity, the empirical model incorporates the sector-specific dummy variables.

Two variables are used for infrastructure service quality: the number of days with power outages (in days per year) and the average duration required to restore an interrupted electricity service (in hours per day), denoted by Z_{P1}, and Z_{P2}, respectively. In our data, these are the most objective measurements to represent the quality of infrastructure services that each enterprise receives.[22]

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[20] Some approximation is often necessary (e.g., Sickles *et al*, 1986;Filippini *et al.*, 2008). An underlying rationale of our variables is that the amount of energy consumed would be relevant to the amount of machinery, equipment, or more generally, assets owned by each firm. In addition, it is noteworthy that this imputed energy price varies across firms by construction. It is not any single unit price of electricity or gas that is often applied to a certain group of firms in a particular area. Rather, this variable reflects not only various pubic energy prices but also the cost of having private backup generators and other energy alternatives. Notably, however, the major energy source for firms is electricity in the SEE region, as mentioned above.

[21] Some of the implied prices are statistically considered outliers; but the estimation results have been found broadly robust regardless of whether or not to include those outliers, as will be seen below.

[22] They are not subjective assessment by firms, but to a certain extent the variables may reflect some subjective judgment by respondents in the surveys. The variables can be misreported and biased. But the country-specific fixed-effect models are expected to mitigate these data problems.

There are three empirical remarks on the *Z*'s. First, the BEEPS database provides other measurements of public utility services in the water supply and telecommunications sectors. It is technically possible to incorporate those variables in our model. However, it has been found that the quality of water and telecommunications services would weakly affect firm production (Iimi, 2009); thus, the current paper adopts the electricity-related variables for *Z*.

Second, in Equation (1), *Z*'s are specified as the composite cost function rather than the simple translog cost function (e.g., Kwoka, 2002). This aims at accommodating zero-quality values, i.e., no interruption of service delivery. In such a case, the number of days with service interruptions is zero. It follows, as a logical consequence, that the duration required to restore the service is zero hours. In our sample, a considerable portion of the observations have zero values for Z_k. A popular approach to this problem may be to replace zeros with a small positive value. However, this may cause severe bias in the estimates. Weninger (2003) shows that the Composite approach and Zero-output translog cost function have relatively low bias and the small standard deviation of the estimates. The small value and generalized translog cost function methods are largely biased.[23]

In the current context, the composite approach has several advantages relative to other alternatives. It is expected to be less biased, as mentioned. It also preserves the linear homogeneity property in input prices, even after incorporating the quadratic form for quality measures.[24] Moreover, the Composite approach is computationally tractable and relatively easy to achieve convergence in the maximum likelihood estimator.[25]

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[23] With our data, it is also found that the small value translog cost estimator tends to sensitive to the choice of a small value.

[24] The absence of the linear homogeneity is considered the principle limitation of this approach when it is applied to a multi-product cost function (Baumol *et al*., 1982; Kwoka, 2002). Fortunately, this is not the case in the current framework.

[25] The current paper partly relies on the stochastic-frontier model, which is a maximum likelihood estimator.

The third remark on the *Z*'s is about their interpretation. Recall that Equation (1) explicitly includes the cost of presumably measurable consumption of energy and fuel. Therefore, the direct effect of reduced energy consumption due to outages is supposed to be captured by other variables than *Z*'s. Our quality variables *Z* in principle represent more implicit costs of poor quality services. For example, operatives in a factory may have to wait for electricity restoration without doing anything, when a power outage unexpectedly happens. Still, firms have to pay their normal wages. If power outages damage product quality, this loss will also be captured by *Z*'s. To avoid a possible negative impact of suspended power services, enterprises may have to invest in their own private backup systems. This will create another type of implicit cost of poor quality infrastructure.

To estimate Equation (1), two estimation techniques are employed: seemingly unrelated regression (SUR) and stochastic-frontier analysis (SFA). To have a well-behaved cost function, the following symmetry and homogeneity restrictions are imposed:

$$\beta_{W_iW_j} = \beta_{W_jW_i}, \beta_{Z_kZ_h} = \beta_{Z_hZ_k}, \sum_i \beta_{W_i} = 1, \sum_i \sum_j \beta_{W_iW_j} = 0, \sum_i \beta_{YW_i} = 0, \sum_i \beta_{W_iZ_k} = 0 \tag{2}$$

For the SUR model, in addition, the following factor share equations are obtained from Shephard's lemma:

$$S_i = \frac{\partial \ln C}{\partial \ln W_i} = \beta_{W_i} + \sum_j \beta_{W_iW_j} \ln W_j + \beta_{YW_i} \ln Y + \sum_k \beta_{W_iZ_k} Z_k \tag{3}$$

where S_i is the cost share of input *i*. Through the SUR model, the cost parameters are estimated in Equation (1) and two of the factor share equations (3).[26] An advantage of the SUR is that higher efficiency in estimation is expected without wasting the degree of freedom (Christensen and Greene, 1976). A disadvantage may be that a strict cost

[26] One of the factor equations should be dropped to avoid the singularity problem.

minimization proposition must be imposed (Kwoka, 2002). By construction, the SUR model assumes allocative and technical efficiencies; any deviation from the frontier is captured by statistical errors, and thus it cannot control for technical inefficiency in an explicit manner (e.g., Berger and Mester, 1997). This may raise certain concern in the present context, because it is less likely that enterprises in transition economies are strictly following the cost minimization proposition.

In order to directly incorporate the possible technical inefficiency, the paper also applies the stochastic-frontier model, in which the assumptions of allocative and technical efficiency are not imposed and firm costs are allowed to deviate from the efficient frontier due to some unknown factors, X-inefficiency (e.g., Coelli, 1992; Berger and Mester, 1997). In the SFA, the error term is composed of two parts: a non-negative technical inefficiency, u and an idiosyncratic error term, v. The error term in Equation (1) is defined as:

$$\varepsilon = \ln u + \ln v \tag{4}$$

where $\ln u$ is assumed to be independently and identically distributed (i.i.d.) according to a half normal distribution $|N(0,\sigma_u)|$, and $\ln v$ is i.i.d. according to a standard normal distribution $N(0,\sigma_v)$.

Given our initial motivation of the paper, the following point estimates are investigated under the above framework. First, the price elasticities of demand for factors of production are calculated from the conventional Allen’s partial elasticities of substitution. The elasticity between inputs i and j is denoted by σ_{ij} and given by this (e.g., Uzawa, 1962; Berndt and Wood, 1975):

$$\sigma_{ij} = \begin{cases} (\beta_{W_iW_j} + S_iS_j)/S_iS_j & \text{if } i \neq j \\ (\beta_{W_iW_i} + S_i^2 - S_i)/S_i^2 & \text{if } i = j \end{cases} \tag{5}$$

Then, the price elasticity of demand for factor *i* associated with price *j* is:

$$\eta_{ij} = S_j \sigma_{ij} \tag{6}$$

Of particular interest is the implied own price elasticity of energy demand:

$$\eta_{EE} = (\beta_{W_E W_E} + S_E S_E - S_E) / S_E \tag{7}$$

Second, the conditional factor demand elasticity with respect to output is calculated. This aims to address the question of how the industrial energy demand would respond to a global economic slowdown, as experienced currently. Given the cost function Equation (1) and Shephard's lemma, the conditional demand elasticity for factor *i* with respect to output *y* is written by:

$$\theta_i \equiv \frac{\partial X_i}{\partial Y}\frac{Y}{X_i} = (C/Y)W_i^{-1}\left[\beta_{YW_i} + S_i(\beta_Y + \beta_{YW_i}\ln W_i)\right] \tag{8}$$

where X_i denotes the derived conditional demand for factor *i* given output *Y*. It is clear that the conditional factor demand elasticity is dependent on four factors: unit cost (i.e., *C/Y*), factor price level, factor share in total costs, and the output elasticity of total costs. If unit cost is high, it means production is input-intensive. Thus, the elasticity tends to be high holding everything constant. Similarly, the elasticity increases with the factor share S*i*. If the factor price is high, the elasticity will be small because of the possible substitution effect between factors. Finally, if the whole cost is elastic to output, then the factor demand elasticity is also sensitive to the level of output. The more output, the more cost. Therefore, more inputs are required.

In addition to these two main issues in question, two more estimates are inferred: cost elasticity with respect to factor price and technical (in)efficiency. Apparently, the former must of necessity be related to the factor share equation (3). By Shephard's lemma, the predicted share equation can be used to assess how the total cost would respond to a change in factor prices. This is of particular interest from the country's economic competitiveness perspective. Any price change will have a cost implication for firms. Given an exogenous shock on energy prices, the economy may lose its competitiveness if increased energy prices increase firms' operating costs significantly. Conversely, if the cost elasticity with respect to energy prices is small, the economy would be less vulnerable to exogenous energy shocks.

Finally, the paper will pay attention to the degree of technical (in)efficiency, which is computed as the difference between the linear prediction of cost and the possible frontier. One advantage of pooling micro data from different countries is that the relative technical inefficiency of each country can be inferred from the estimated function. The estimated technical inefficiency in cost terms is defined by:

$$u = E\left[\exp(\ln u \mid \varepsilon)\right] \tag{9}$$

This allows us to measure to what extent each firm's production would involve technical inefficiency, which may include energy inefficiency. The following analysis calculates u/C as a primary technical inefficiency index.

The used data come from the 2005 BEEPS for 7 countries in the SEE region. The sample size amounts to about 1,000. This excludes a number of observations of which the relevant cost data are not available.[27] The number of observations per country in our sample varies from 79 in Bosnia and Herzegovina to 269 in Romania, but mostly around 150.

[27] The original sample size of the BEEPS covering the seven countries is 2,040. Although the data selection is merely dependent on data availability and thus considered fairly automatic, one might be concerned that there might be the self-selection mechanism where the data availability would be correlated with certain cost characteristics of firms. This is hardly testable by nature, but one possible indication could be the Wilcoxon rank-sum test, which hypothesizes the sampled and non-sampled observations would be drawn from the same population distribution. There are a number of observations in our data, for which C is available but other data items are missing so that they are not used for the analysis. The Wilcoxon test statistic varies across countries;

(continued)

The summary statistics are shown in Table 2. Firms look different in size as well as factor intensity. The operating cost ranges from 10,000 to 423 million U.S. dollars with a mean of about 3.9 million U.S. dollars. The average wage is estimated at around US$ 5,400 per annum. In the sample the labor cost amounts to 22 percent of total costs on average. However, the degree of labor intensity varies considerably from nearly zero to 81 percent. The energy cost share also differs between nil to 66 percent with an average of about 8 percent. The number of days without sufficient electricity supply reaches 28 days per year on average. The average duration needed for power restoration is about 2 hours. But these levels of public electricity services are markedly different from country to country and across regions within each country. Table 3 shows simple correlations between these variables.

Table 2. Summary Statistics

Variable		Obs	Mean	Std. Dev.	Min	Max
C	Operating cost	990	3,875	17,891	10	423,860
Y	Output (total sales)	990	4,468	20,407	15	469,362
W_L	Wage (average per full time employee)	990	5.39	4.43	0.33	81.13
W_E	Energy and fuel price	990	0.73	2.74	0.00	67.00
W_K	Capital price	990	11.21	63.61	0.02	1841.00
S_L	Cost share of labor expenses (0 to 1)	990	0.22	0.14	0.01	0.81
S_E	Cost share of energy and fuel expenses (0 to	990	0.08	0.08	0.00	0.66
Z_{P1}	Days without electricity supply a year	990	28.44	82.73	0.00	365.00
Z_{P2}	Duration of electricity suspension in hours	990	1.99	3.38	0.00	24.00
Sector dummy						
	Mining	990	0.02	0.13	0	1
	Construction	990	0.09	0.29	0	1
	Manufacturing	990	0.41	0.49	0	1
	Transport	990	0.07	0.26	0	1
	Trade	990	0.23	0.42	0	1
	Real estate	990	0.07	0.25	0	1
	Hotels and restaurant	990	0.07	0.25	0	1
	Other services	990	0.05	0.21	0	1

Note: All monetary variables are in thousands of U.S. dollars; unless otherwise, indicated.

the hypothesis cannot be rejected in all the countries but Bulgaria and Romania. For further data sampling issues, see World Bank (2007a).

Table 3. Correlation

	C	Y	W_E	W_L	W_K	Z_{P1}	Z_{P2}	S_L
Y	0.998							
W_L	0.123	0.120						
W_E	-0.014	-0.014	-0.002					
W_K	0.023	0.024	0.018	0.880				
Z_{P1}	0.017	0.025	-0.033	-0.006	-0.009			
Z_{P2}	-0.001	0.002	-0.013	-0.024	-0.008	0.183		
S_L	-0.099	-0.099	0.171	-0.046	-0.102	0.052	-0.025	
S_E	-0.091	-0.092	-0.064	0.156	-0.072	0.000	-0.016	0.101

V. Main Estimation Results

Both SUR and SFA models are estimated with data from seven SEE countries; the results are shown in Table 4.[28] The coefficients are broadly consistent with economic theory; recall that the current paper relies on a simple firm cost minimization model and assumes that a certain group of firms would share the same cost function. The coefficient of output Y is positive and significant, and the operating cost increases with unit labor costs (wages) as well as energy and fuel expenditures. The coefficients are not dramatically different between the two models, though the statistical significance may change for some of the coefficients.

Price elasticities of factor demand

Given the estimated cost parameters, the own price elasticities of demand for production factors are evaluated at the sample means by the delta method (Equation (6)). All the own price elasticities are found significantly negative and consistent with economic theory (Table 5). The price elasticity of industrial energy demand in question is estimated at –0.403 by the SUR regression and –0.366 by the SFA model. Therefore, on average, one can expect that a 10-percent increase in energy prices would reduce the industrial demand for energy by about 4 percent. These estimates are within the conventional range supported by the existing literature (e.g., Taylor, 1975; Bernstein and Griffin, 2005), and seem to be relatively inelastic, though not extraordinarily.

[28] The results have been found indifferent about whether or not to include country-specific fixed effects. In addition, it has also been found robust against the clustering of errors by country and sector. Therefore, the following discussion will mainly present the unclustered estimation results without the country fixed effects.

Table 4. Estimated cost function with data from 7 SEE countries

	SUR	SUR	SFA	SFA	SFA (Clustered by industry)	SFA (Clustered by country)
	All countries	All countries	All countries	All countries	All countries	All countries
β_Y	0.866 (0.025) ***	0.859 (0.027) ***	0.858 (0.031) ***	0.859 (0.031) ***	0.858 (0.037) ***	0.867 (0.014) ***
β_{YY}	0.005 (0.004)	0.004 (0.004)	0.002 (0.004)	0.004 (0.004)	0.002 (0.004)	0.004 (0.004)
β_{W_L}	0.611 (0.015) ***	0.830 (0.022) ***	0.816 (0.032) ***	0.830 (0.032) ***	0.816 (0.061) ***	0.834 (0.034) ***
β_{W_E}	0.091 (0.017) ***	−0.047 (0.030)	−0.042 (0.060)	−0.047 (0.055)	−0.042 (0.131)	−0.053 (0.073)
$\beta_{W_L W_L}$	−0.007 (0.006)	−0.130 (0.014) ***	−0.135 (0.021) ***	−0.130 (0.021) ***	−0.135 (0.020) ***	−0.126 (0.018) ***
$\beta_{W_L W_E}$	0.132 (0.003) ***	0.202 (0.007) ***	0.225 (0.010) ***	0.202 (0.010) ***	0.225 (0.011) ***	0.203 (0.009) ***
$\beta_{W_L W_K}$	−0.136 (0.003) ***	−0.147 (0.008) ***	−0.165 (0.012) ***	−0.147 (0.012) ***	−0.165 (0.015) ***	−0.149 (0.010) ***
$\beta_{W_E W_E}$	0.070 (0.004) ***	0.049 (0.009) ***	0.048 (0.016) ***	0.049 (0.015) ***	0.048 (0.015) ***	0.047 (0.013) ***
$\beta_{W_E W_K}$	0.010 (0.004) ***	0.016 (0.008) *	0.018 (0.013)	0.016 (0.012)	0.018 (0.008) **	0.017 (0.011)
β_{YW_L}	0.004 (0.002) *	0.009 (0.003) ***	0.010 (0.003) ***	0.009 (0.003) ***	0.010 (0.005) **	0.009 (0.003) ***
β_{YW_E}	−0.019 (0.002) ***	−0.030 (0.005) ***	−0.035 (0.007) ***	−0.030 (0.006) ***	−0.035 (0.013) ***	−0.029 (0.007) ***
$\beta_{Z_{P1}}$	0.001 (0.001)	−0.000 (0.001)	−0.001 (0.001)	−0.000 (0.001)	−0.001 (0.001)	−0.000 (0.001)
$\beta_{Z_{P2}}$	0.014 (0.008) *	0.011 (0.009)	0.018 (0.009) *	0.011 (0.008)	0.018 (0.009) **	0.010 (0.005) **
$\beta_{Z_{P1}Z_{P1}}$	−1.4E-6 (2.4E-6)	4.8E-7 (2.9E-6)	1.2E-6 (2.0E-6)	4.8E-7 (2.6E-6)	1.2E-6 (1.4E-6)	5.4E-7 (1.5E-6)
$\beta_{Z_{P1}Z_{P2}}$	−3.6E-5 (4.0E-5)	6.4E-6 (4.3E-5)	4.0E-6 (2.7E-5)	6.4E-6 (2.8E-5)	4.0E-6 (1.3E-5)	7.0E-6 (4.3E-5)
$\beta_{Z_{P2}Z_{P2}}$	4.3E-4 (5.0E-4)	4.7E-4 (5.2E-4)	2.7E-4 (4.1E-4)	4.7E-4 (3.9E-4)	2.7E-4 (3.9E-4)	4.9E-4 (3.1E-4)
$\beta_{YZ_{P1}}$	−8.5E-6 (5.9E-5)	2.1E-5 (6.7E-5)	3.2E-5 (4.4E-5)	2.1E-5 (4.9E-5)	3.2E-5 (3.9E-5)	2.1E-5 (4.1E-5)
$\beta_{YZ_{P2}}$	−3.5E-4 (1.0E-3)	1.2E-3 (1.2E-3)	1.2E-3 (1.0E-3)	1.2E-3 (9.6E-4)	1.2E-3 (9.6E-4)	1.0E-3 (7.5E-4)
$\beta_{W_L Z_{P1}}$	7.0E-5 (4.5E-5)	7.9E-5 (6.3E-5)	1.2E-4 (5.1E-5) **	7.9E-5 (5.4E-5)	1.2E-4 (4.8E-5) **	6.6E-5 (5.4E-5)
$\beta_{W_L Z_{P2}}$	−1.1E-3 (9.8E-4)	−2.2E-3 (1.3E-3) *	−2.1E-3 (1.2E-3) *	−2.2E-3 (1.1E-3) **	−2.1E-3 (7.3E-4) ***	−2.0E-3 (6.3E-4) ***
$\beta_{W_E Z_{P1}}$	9.5E-6 (5.4E-5)	−1.5E-5 (1.2E-4)	−6.3E-5 (1.2E-4)	−1.5E-5 (1.1E-4)	−6.3E-5 (1.6E-4)	−1.3E-5 (1.2E-4)
$\beta_{W_E Z_{P2}}$	2.8E-3 (1.3E-3) **	6.9E-3 (2.7E-3) **	8.2E-3 (3.7E-3) **	6.9E-3 (3.3E-3) **	8.2E-3 (2.7E-3) ***	6.2E-3 (2.0E-3) ***
Construction	0.028 (0.060)	0.026 (0.063)	0.047 (0.054)	0.026 (0.051)	0.047 (0.043)	
Manufacturing	0.081 (0.056)	0.069 (0.060)	0.105 (0.049) **	0.069 (0.047)	0.105 (0.042) **	
Transport	−0.045 (0.061)	0.061 (0.065)	0.089 (0.063)	0.061 (0.059)	0.089 (0.045) **	
Trade	0.021 (0.058)	0.057 (0.061)	0.076 (0.051)	0.057 (0.048)	0.076 (0.038) **	
Real estate	−0.071 (0.062)	−0.062 (0.066)	−0.034 (0.059)	−0.062 (0.056)	−0.034 (0.044)	
Restaurant & hotel	0.005 (0.062)	0.027 (0.065)	0.038 (0.061)	0.027 (0.057)	0.038 (0.047)	
Other services	−0.046 (0.065)	0.007 (0.069)	0.020 (0.065)	0.007 (0.061)	0.020 (0.061)	
Constant	−0.355 (0.109) ***	−0.751 (0.118) ***	−0.521 (0.164) ***	−0.752 (0.165) ***	−0.521 (0.368)	−0.742 (0.145) ***
Obs.	990	990	990	990	990	990
Country fixed effects	No	Yes	No	Yes	No	No
Chi-square						
Cost equation	84577.2	85290.3	97692.7	107266		
Wage share equation	2388.6	2330.2				
Energy cost share equat	9613.4	8464.9				

Note that the dependent variable is the logarithmic operating cost. The standard errors are shown in parentheses. *, ** and *** represent the 10%, 5% and 1% level significance, respectively.

Table 5. Price elasticity of demand for production factor

	All countries		Excluding Albania	
	SUR	SFA	SUR	SFA
η_{LL}	−0.769 ***	−1.468 ***	−0.763 ***	−1.492 ***
	(0.022)	(0.114)	(0.024)	(0.122)
η_{EE}	−0.403 ***	−0.366 **	−0.383 ***	−0.307 *
	(0.021)	(0.168)	(0.022)	(0.175)
η_{KK}	−0.536 ***	−0.277 ***	−0.542 ***	−0.273 ***
	(0.012)	(0.030)	(0.013)	(0.032)

The standard errors are shown in parentheses. *, ** and *** represent the 10%, 5% and 1% level significance, respectively.

One potential concern may be that the estimation results might be sensitive to outliers, especially in the implied factor prices. With the observations beyond the conventional upper outer fence excluded, the same models are estimated.[29] The price elasticity of energy demand is estimated at –0.252 with a standard error of 0.032 in the SUR specification. This appears slightly lower than the previous estimate with outliers included but remains statistically significant and within the conventional range in the literature.

One may also be concerned that pooling data from Albania, in which the quality of electricity services was extremely bad in the sample period, would create significant statistical noise in our case. Recall that the country experienced massive power outages around the sample year. With 118 observations from Albania discarded, the price elasticity is estimated under the same framework; the result has been found mostly unchanged, regardless of whether Albania's data are included or not (Table 5).[30] The energy elasticity may be slightly lower than before. This implies that a large variation in the public energy supply conditions in Albania might play a certain role in exaggerating the measured demand response in other countries.

For the same reason, one may think that different countries would have different economic structures and thus respond to a possible change in energy prices differently. One empirical approach to address this problem is to estimate the model separately for each country and evaluate the price elasticities within its own country data. A great advantage of this separate strategy is that the cost structure is no longer assumed the same among countries.[31] Moreover, the estimates are independent of any country-specific fixed unobservables, which could potentially generate the omitted variable bias in the pooled model. On the other hand, one of the significant disadvantages of the separate estimation approach is obviously the relatively small sizes of country subsamples. In particular in our specification, there are a

[29] The upper outer fences are estimated at 19.75 for W_L, 1.06 for W_E, and 15.14 for W_K, respectively. In total, 195 observations are excluded from the sample, leaving 797 observations as non-outliers.

[30] The estimated cost function is presented in Appendix Table A1.

[31] An alternative may be to evaluate the pooled model at each country's sample means. However, it mans that the cost structure is still assumed to be the same across countries. It may be a relatively strong assumption to impose the same cost structure on all countries.

relatively large number of parameters to be estimated, compared with the number of observations in each country. Not surprisingly, therefore, the SFA regression will tend to be destabilized.[32]

The price elasticities estimated by the SFA technique tend to be larger than the SUR estimates, but some of the implied elasticities have lost statistical significance. In cases where both models are significant, the elasticity for Macedonia is about –1.0, instead of –0.76. For Serbia, the SFA provides an elasticity of –0.89, instead of –0.37. When comparing the price elasticities of demand for energy according to the SUR results, Albania and Macedonia are estimated to have the particularly elastic demand for energy; the elasticities are –0.77 and –0.76, respectively (Table 6).[33] For other countries, the price elasticities are relatively low in absolute terms at 0.2 to 0.4. The lowest elasticity is estimated at –0.21 for Romania (Figure 14). This may reflect the fact that the country's economic structure still involves the large energy-intensive, unrestructured public sector.

Table 6. Price elasticity of demand for production factor by country

	Albania	Bosnia & Herzegovin		Bulgaria		Croatia		Macedonia		Romania		Serbia	
	SUR	SUR	SFA	SUR	SFA	SUR	SFA	SUR	SFA	SUR	SFA	SUR	SFA
η_{LL}	–0.886 ***	–0.900 ***	–3.340 *	–0.450 ***	–1.140 ***	–1.070 ***	–3.060 *	–0.740 ***	–0.760 ***	–0.620 ***	–1.480 ***	–1.045 ***	–2.981 ***
	(0.055)	(0.080)	(1.720)	(0.080)	(0.110)	(0.040)	(1.680)	(0.060)	(0.130)	(0.060)	(0.280)	(0.077)	(0.718)
η_{EE}	–0.774 ***	–0.260 ***	0.620	–0.330 ***	–4.060	–0.370 ***	0.400	–0.760 ***	–1.010 ***	–0.210 ***	–0.300	–0.372 ***	–0.896 ***
	(0.088)	(0.080)	(0.260)	(0.050)	(10.610)	(0.050)	(1.370)	(0.090)	(0.270)	(0.070)	(1.180)	(0.105)	(0.389)
η_{KK}	–0.438 ***	–0.450 ***	–0.150 **	–0.670 ***	–0.260 ***	–0.390 ***	–0.020	–0.480 ***	–0.450 ***	–0.560 ***	–0.200 ***	–0.321 ***	–0.017
	(0.030)	(0.030)	(0.070)	(0.040)	(0.060)	(0.020)	(0.060)	(0.050)	(0.100)	(0.020)	(0.050)	(0.023)	(0.044)

The standard errors are shown in parentheses. *, ** and *** represent the 10%, 5% and 1% level significance, respectively.

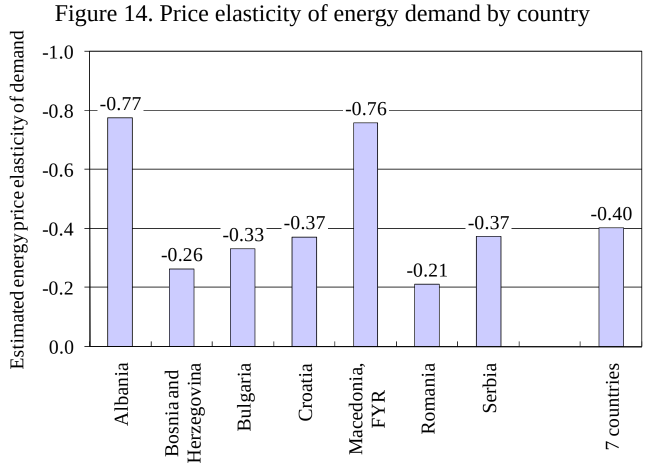
The significant difference may indicate that the effectiveness of price adjustments to balance demand and supply would be different from country to country. Bearing in mind a variety of assumptions and restrictions imposed on our empirical models, this can be interpreted to mean that even though the same price policy is implemented, in some countries, such as Albania and Macedonia, it would be a powerful tool, but in other countries, it may not be effective enough. Note that this is an estimation result, given the currently available data;

[32] In the case of Albania, in fact, the SFA model does not converge successfully.

[33] The estimated cost functions are presented in Appendix Tables A2 to A8.

with more detailed data, the estimates could be refined further. The difference may result from different industrial structures among countries. As discussed below, the price elasticity differs across industries. The difference in elasticities may also reflect each economy's tendency toward new energy-efficient technology. Some countries may have better access to advanced knowledge, and others may be faced with financial difficulties in adopting new technology. Ownership may also matter. Typically, state-owned enterprises or other public entities, which may be covered in the sample, are often irresponsive to price signals. They may continue to use as much energy, labor and other input as they need.

Figure 14. Price elasticity of energy demand by country



The difference in price elasticities across countries remains consistent even if some firm-level unobservable characteristics are partially taken into account. With the 2005 data merged with the 2009 BEEPS, the fixed-effect SUR models are estimated; Albania and Macedonia are estimated to have the relatively elastic demand for energy, though the levels of elasticities are different from the cross-section case (Table 7).[34] [35] Note that the sample data are highly unbalanced; the samples have an overlap of only about 10 percent, as far as the observations have sufficient data items to estimate the cost function under the current approach. Therefore, the models do not eliminate all the heterogeneity in firms but partially

[34] In addition, the panel analysis incorporated more detailed sectoral classification; the manufacturing sector can be disaggregated. As the result, 18 industrial dummy variables are included.

[35] The estimated cost functions are presented in Appendix Tables A9.

control for some unobservables at the firm and much broader levels, e.g., countries and sectors.

Table 7. Price elasticity of energy demand by unbalanced panel analysis

	Unbalanced SUR with fixed effects		
Pooled model			
All 7 countries	–0.159	(0.044)	***
Separate models			
Albania	–0.434	(0.090)	***
Bosnia & Herzegovina	–0.261	(0.089)	***
Bulgaria	–0.236	(0.056)	***
Croatia	–0.276	(0.067)	***
Macedonia	–0.370	(0.133)	***
Romania	–0.209	(0.077)	***
Serbia	–0.111	(0.132)	

*, ** and *** represent the 10%, 5% and 1% level significance, respectively.

By industry, construction and manufacturing seem to have relatively low price elasticities of energy demand, though the frontier analysis generates insignificant coefficients (Table 8). With the pooled SUR regression estimated with the 2005 data and evaluated at the sample means of each industry, the elasticities are estimated at less than 0.2 in the construction and manufacturing sectors (Figure 15).[36] In other industries, which mainly belong to the service sector, the energy demand can be considered more elastic. The main results are found unchanged when the cost function is estimated for each industry separately, even though the level of the elasticities is different.[37] An important policy implication from the Ramsey rule is that governments should charge more on the construction and manufacturing industries to maximize economic efficiency, because their demand are less likely to react to high tariffs. However, as already discussed, an application of the Ramsey rule to the real economy may raise the equity concern and the risk of reducing competitiveness of key industries. It may not be justifiable that two companies consuming the same amount of electricity are charged

[36] One unexpected result may be that the price elasticity of the manufacturing sector is not statistically insignificant in the SFA model. In general, it is expected that manufacturing would be more energy intensive and more flexible in their technology choice.

[37] In this case, the country-specific fixed-effects are included, rather than the industry-specific ones. For the mining sector, there is no sufficient observation to estimate the assumed cost function (Equation (1)).

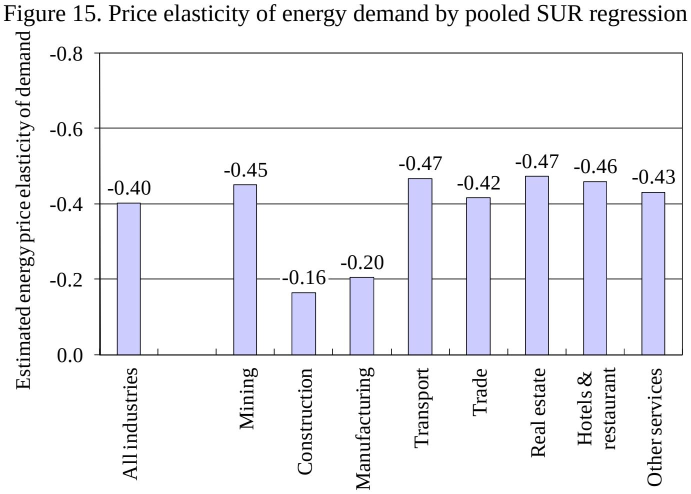
different prices just because they belong to different industries. And heavily charged industries will be losing competitiveness, if their products are tradables.

Table 8. Price elasticity of energy demand by industry

	Pooled data with industry-specific fixed effects						Separate SUR regressions by industry		
	SUR			SFA					
All industries	–0.403	(0.021)	***	–0.366	(0.168)	**	…		
By industry:									
Mining	–0.451	(0.017)	***	–0.532	(0.099)	***	…		
Construction	–0.165	(0.052)	***	0.145	(0.538)		–0.446	(0.118)	***
Manufacturing	–0.205	(0.038)	***	1.584	(2.266)		–0.348	(0.047)	***
Transport	–0.467	(0.014)	***	–0.529	(0.082)	***	–0.237	(0.044)	***
Trade	–0.416	(0.022)	***	–0.443	(0.156)	***	–0.340	(0.103)	***
Real estate	–0.473	(0.014)	***	–0.561	(0.075)	***	–0.742	(0.099)	***
Hotels & restaurant	–0.459	(0.015)	***	–0.524	(0.089)	***	–0.895	(0.151)	***
Other services	–0.431	(0.021)	***	–0.473	(0.131)	***	0.071	(0.225)	

The standard errors are shown in parentheses. *, ** and *** represent the 10%, 5% and 1% level significance, respectively.

Figure 15. Price elasticity of energy demand by pooled SUR regression



Conditional energy demand elasticity with respect to output

The implied conditional factor demand elasticity with respect to output can also be calculated by evaluating the SUR results at the sample means. The average response of nonresidential energy demand to a marginal shock in output is estimated at 0.056 in the pooled model but ranges from 0.07 to 0.17 in the country-specific models (Table 9). Hence, if the output demand declines exogenously by 10 percent, the nonresidential demand for energy would decrease by 0.7 to 1.7 percent. Recall, again, that the majority of enterprises in the economy normally spend 5 to 9 percent of total costs for energy consumption. Therefore, the marginal impact of changes in any single factor price is of necessity partial. Also it is noteworthy that the figure is the average effect. Energy-intensive industries are outliers in the sample, and their behavior may not be well captured in this average elasticity. As indicated in Equation (8), the conditional factor demand elasticity tends to be larger if firms spend more for energy (i.e., higher cost share S_E and higher unit cost C/Y).

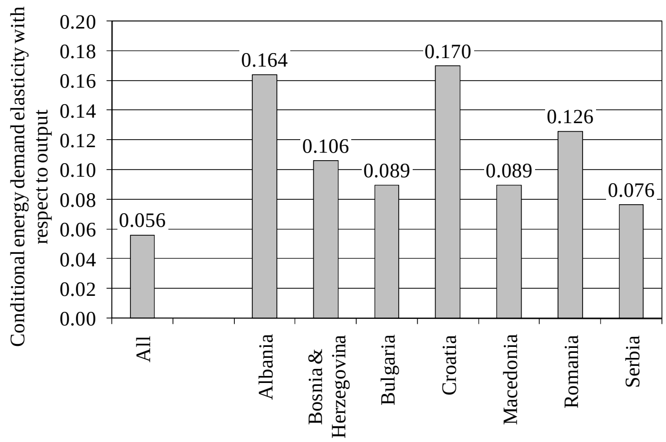
In cross-country comparison, Albania and Croatia are found to have high conditional energy demand elasticities with respect to output (Figure 16). Given an economic downturn, the industrial demand for energy is expected to respond relatively quickly in those countries. In Bulgaria and Macedonia, the energy demand will decline in response to a demand reduction for product, but relatively modestly.

Table 9. Conditional energy demand elasticity with respect to output

	SUR
Pooled model	
All 7 countries	0.056 ***
	(0.004)
Separate models	
Albania	0.164 ***
	(0.050)
Bosnia & Herzegovina	0.106 ***
	(0.028)
Bulgaria	0.089 ***
	(0.020)
Croatia	0.170 ***
	(0.027)
Macedonia	0.089 ***
	(0.027)
Romania	0.126 ***
	(0.033)
Serbia	0.076 ***
	(0.013)

*, ** and *** represent the 10%, 5% and 1% level significance, respectively.

Figure 16. Conditional energy demand elasticity with respect to output by SUR regressions



Cost elasticity with respect to energy prices

The estimated cost parameters allow us to infer the cost response to a possible change in energy prices. When evaluating the SUR results at the sample means, the energy price elasticity of total costs is estimated at 0.15 for all samples, meaning that a 10 percent increase in energy prices would result in increasing firm costs by 1.5 percent (Table 10). This is a marginal effect, holding everything else constant. In reality, however, an increase in energy prices would incentivize firms to economize on energy consumption and replace it with other inputs, if possible. Therefore, the net impact of increased energy prices on total costs may be much more moderate. In fact, the average propensity of energy spending is about 5 to 9 percent of total costs (see Figure 7), which is equalized to the energy price elasticity of costs in theory.

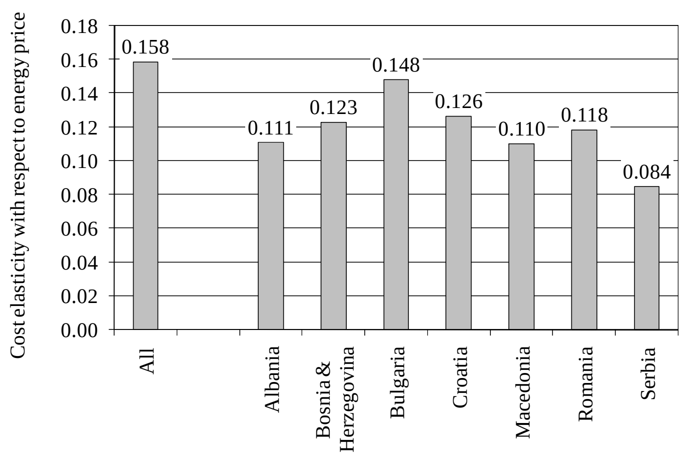
By country, Bulgaria has the highest elasticity of 0.148, followed by Croatia and Bosnia and Herzegovina (Figure 17). In the short run, these countries are considered more vulnerable to instantaneous energy price increases. In the same vein, these countries may also be potential short-term beneficiaries from a drop in energy prices.

Table 10. Cost elasticity with respect to energy prices

	SUR	
Pooled model		
All 7 countries	0.158	***
	(0.007)	
Separate models		
Albania	0.111	***
	(0.027)	
Bosnia & Herzegovina	0.123	***
	(0.016)	
Bulgaria	0.148	***
	(0.018)	
Croatia	0.126	***
	(0.014)	
Macedonia	0.110	***
	(0.021)	
Romania	0.118	***
	(0.011)	
Serbia	0.084	***
	(0.012)	

*, ** and *** represent the 10%, 5% and 1% level significance, respectively.

Figure 17. Cost elasticity with respect to energy prices by SUR regressions



Other characteristics of estimated cost functions

Besides price elasticities, there are at least two important characteristics of the estimated cost structure of SEE firms. From the industrial organization point of view, first, one interesting question is whether the cost function exhibits economies of scale in production.[38] When evaluated at the sample means, the output elasticities of costs in the pooled models shown in Table 4 are estimated at 0.956 with a standard error of 0.008 and 0.968 with a standard error

[38] See, for example, Kolstad and Turnovsky (1998), Kleit and Terrell (2001), and Filippini and Wild (2001).

of 0.007, respectively (Table 11). The estimates are strongly significant and different from unity. It is implied that firms could produce more at relatively small additional operating costs. For instance, every input of $95.6 or $96.8 could produce a value of $100, leaving a profit of $4.4 or $3.2.

However, the degree of economies of scale in production may differ among countries. The hypothesis that the output elasticity of cost is significantly different from unity can be rejected at the conventional 5 percent level for only Bulgaria and Romania (Table 11). This seems reasonable because these two countries are the two largest in the SEE region. It is likely that those economies would benefit from economies of scale and agglomeration in production and service provision. On the other hand, the rest are much smaller, except for Serbia.[39] In those countries, it may be more difficult to take advantage of the scale effect in any economic activity.

Table 11. Output elasticity of total costs

	SUR	SFA
Pooled model		
All 7 countries	0.956 ***	0.968 ***
	(0.008)	(0.008)
Excluding Albania	0.954 ***	0.964 ***
	(0.009)	(0.009)
Separate models		
Albania	0.992 ***	...
	(0.014)	...
Bosnia & Herzegovina	0.986 ***	1.007 ***
	(0.024)	(0.030)
Bulgaria	0.925 ***	0.907 ***
	(0.028)	(0.041)
Croatia	0.986 ***	0.979 ***
	(0.015)	(0.014)
Macedonia	0.997 ***	1.039 ***
	(0.029)	(0.032)
Romania	0.942 ***	0.967 ***
	(0.012)	(0.013)
Serbia	0.990 ***	1.001 ***
	(0.013)	(0.010)

*, ** and *** represent the 10%, 5% and 1% level significance, respectively.

[39] The population of Romania is about 12 million. Bulgaria has a population of 7.6 million. Serbia also has 7.4 million. The other SEE countries have 2 to 4 million of population.

The second characteristic revealed by the estimated cost function is that the poor quality of public electricity services might have an adverse effect on firm costs. However, the statistical significance is still open to argument. Based on the pooled models, the cost elasticities with respect to infrastructure quality measures, Z_{P1} and Z_{P2}, are evaluated at the sample means (Table 12). It is found that the elasticity with respect to power outage duration is significantly positive at 0.015, meaning that quick recovery from power outages would help enterprises avoid unnecessary extra costs and contribute to improving firm competitiveness. However, the other elasticities are statistically insignificant, though largely positive as expected. By country, the country-specific models for Bulgaria and Macedonia provide the positive and significant cost elasticity associated with the average duration of power outages.

Table 12. Cost elasticity with respect to power service quality

	SUR		SFA	
	$ZP1$	$ZP2$	$ZP1$	$ZP2$
Pooled model				
All 7 countries	0.007	0.008	–0.009	0.015 *
	(0.011)	(0.010)	(0.009)	(0.009)
Excluding Albania	0.001	0.007	–0.002	0.014
	(0.009)	(0.010)	(0.009)	(0.009)

* represents the 10% level significance.

Estimated technical (in)efficiency

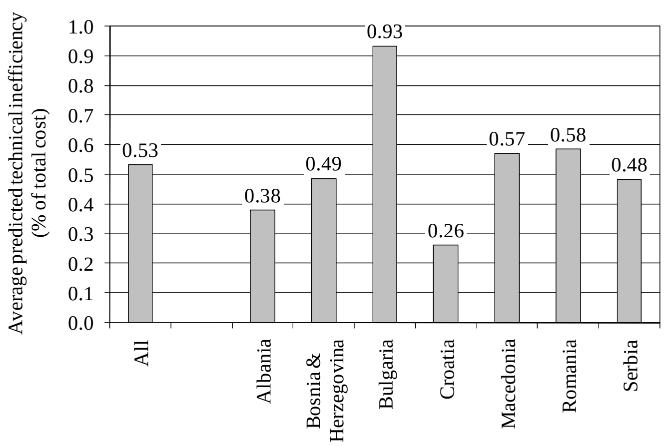
The stochastic-frontier analysis with pooled data allows us to assess to what extent individual firms are economically inefficient. A technical efficiency index is computed as the distance of the linearly predicted cost from the possible frontier (Equation (9)). On average, the sample enterprises are predicted to be operating 0.53 percent below the maximum possible efficient frontier (Table 13). This can be understood as the average technical inefficiency among typical firms in the SEE transition economies. The measured inefficiency seems to vary from country to country. While Croatia has a minimum technical inefficiency of 0.26 percent, Bulgaria has a maximum inefficiency of 0.93 percent (Figure 18). For the rest, the average technical inefficiency is around 0.4 percent.

It is also shown that the service industry involves more technical inefficiency than the secondary sector. In the real estate, hotels and restaurants, and other service industries, the potential technical inefficiency is predicted to exceed 0.8 percent of total costs. Mining is considered the most efficient industry in our sample.

Table 13. Average predicted technical inefficiency by country and by sector (% of total costs)

	Obs	Mean	Std. Dev.	Min	Max
All sample	990	0.53	0.94	0.000	10.01
By country:					
Albania	118	0.38	0.45	0.001	2.63
Bosnia & Herzegovina	79	0.49	0.81	0.004	4.55
Bulgaria	141	0.93	1.45	0.001	6.67
Croatia	172	0.26	0.44	0.000	2.71
Macedonia	89	0.57	0.76	0.002	4.35
Romania	269	0.58	1.05	0.003	10.01
Serbia	122	0.48	0.84	0.002	5.01
By industry:					
Mining	16	0.21	0.32	0.004	1.21
Construction	94	0.27	0.36	0.002	2.09
Manufacturing	403	0.40	0.66	0.001	5.56
Transport	72	0.37	0.74	0.003	5.56
Trade	226	0.56	0.81	0.000	5.56
Real estate	65	0.87	1.52	0.006	6.67
Hotels & restaurant	67	0.83	1.14	0.003	4.55
Other services	47	1.52	2.00	0.016	10.01

Figure 18. Average predicted technical inefficiency by country



By size of firms, not surprisingly, small and medium enterprises are found relatively inefficient (Table 14). The average firm's technical inefficiency is estimated at 1.66 percent of total costs, if its annual sales are less than US$199,000. But for large firms whose outturn exceeds US$2.5 million, technical inefficiency may account for only 0.02 percent of all operating costs. By labor intensity, enterprises relying more on labor input tend to be less efficient. The evidence seems to be consistent with a common view that labor issues, such as over-employment and low labor quality, are among the most serious constraints on firm efficiency in transition economies.

Finally, energy-intensive firms look less efficient in economic terms. This may be able to be interpreted to mean that some fraction of the predicted technical inefficiency would be relevant to firm spending on energy. This may be because of the existing energy use inefficiency embedded in equipment and production systems or because of some extra costs caused by the existing poor quality of public infrastructure services.

Table 14. Average predicted technical inefficiency by firm characteristics (% of total costs)

	Obs	Mean	Std. Dev.	Min	Max
By firm size:					
$Y < 199$	246	1.66	1.34	0.506	10.01
$199 < Y < 612$	246	0.35	0.13	0.164	0.86
$612 < Y < 2{,}451$	248	0.11	0.05	0.038	0.25
$Y > 2{,}451$	250	0.02	0.01	0.000	0.05
By labor intensity:					
$SL < 0.11$	248	0.28	0.75	0.000	10.01
$0.11 < SL < 0.196$	246	0.44	0.70	0.001	4.55
$0.196 < SL < 0.287$	248	0.59	0.96	0.001	6.67
$SL > 0.287$	248	0.82	1.19	0.004	6.67
By enregy intensity:					
$SE < 0.029$	247	0.23	0.34	0.000	2.38
$0.029 < SE < 0.054$	248	0.54	0.89	0.001	5.27
$0.054 < SE < 0.099$	247	0.60	1.03	0.002	6.67
$SE > 0.099$	248	0.76	1.20	0.001	10.01

VI. POLICY IMPLICATIONS

The following discusses some policy implications of the above findings under simplified circumstances. This is only for illustration purposes; the exact situation of each country may be characterized differently, depending on the specific focus, and it is also changing over time (e.g., IEA, 2008; IPA, 2009). Of particular note, the discussion mainly characterizes the situation around the sample year of the used BEEP data (i.e., in 2004) and may not reflect the latest developments in each country, for instance, prices (Figure 8). It also ignores other energy sources than electricity. Accordingly, the gap between our imputed energy price and the actual non-residential electricity price per kWh could be large, as observed in Bulgaria and Romania. This is a clear limitation to the interpretation of the results in the electricity context, when there are significant energy alternatives, such as natural gas. Even one of the basic dimensions of energy policy needs to be assessed much more carefully. [40]

Based on the general discussion in Section III, Croatia and Romania are characterized by their particularly high nonresidential electricity tariffs. Other countries are assumed to have relatively low rates. The estimation results indicate that the price elasticity of demand would be high in Albania and Macedonia (Figure 14), while the energy demand elasticity with respect to final output is high in Albania and Croatia (Figure 17). In addition, it is shown that technical inefficiency, some of which could be associated with the pattern of energy consumption, is high in Bulgaria, followed by Macedonia and Romania. Finally, based on the discussion on electricity intensity of the economy, suppose that Macedonia and other countries, such as Bulgaria and Serbia, have a particularly significant amount of energy demand from energy-intensive exporting industries, such as iron, steel and nonmetal minerals. These conditions are illustrated in Figure 19.

Predicted demand response to energy crises

Consider an exogenous increase in energy prices. The industrial energy consumption would react strongly in Albania and Macedonia. In both countries, the nonresidential electricity tariffs are not extremely high. Therefore, adjusting prices would be one of the effective policy options to balance demand with supply and strengthen the financial viability and sustainability of the energy sector. One possible setback in the case of Macedonia is that the country’s key industries consuming a lot of energy might also lose competitiveness and reduce production to a large extent or perhaps cease producing. Since the country is heavily dependent on those industries for exports, some other structural adjustments may be needed in tandem with energy price refinements from the broader economic policy perspective. By contrast, Albania may be able to rely easily on the price instrument.

[40] Obviously, further significant efforts are necessary to improve the process of data generation for assessing more specific energy policies in the region.

Another important policy interpretation of the measured large elasticities is this: Suppose that public utility's energy prices increases. Then, firms might be likely to switch their energy sources from public utilities to private backup generators in these countries. This may fundamentally stem from the firms' distrust in the public infrastructure services. In Albania, nearly 15 percent of total sales are estimated to be lost due to power outages (Enterprise Surveys, 2007). About 80 percent of firms in the country have their own backup generators, which are estimated to have generated some 30 percent of firm electricity consumption in 2006. With poor quality public services, firms are more motivated to rely on self-protective measures, which are normally costly for the economy as a whole.

Unlike Albania and Macedonia, the expected demand response is predicted to be very limited in the rest of the countries considered: Croatia, Romania, Bosnia and Herzegovina, Bulgaria and Serbia. In the first two countries, in addition, the electricity tariffs are already significantly high. A risk is evident when these countries focus on price adjustments to balance demand and supply: Electricity prices may be skyrocketing without visible response from consumers. In this case, pricing cannot be the only solution.[41] Notably, this does not mean that pricing would be useless. It is still an essential element in the sector reform to achieve full cost-recovery and phase out cross-subsidies, as stipulated by IEA (2008) and others.[42] One useful, complementary policy measure may be to facilitate reduction in technical inefficiency. Recall that Romania's predicted technical inefficiency at the firm level is twice as high as the regional best performer in this regard, Croatia. Hence, the country can

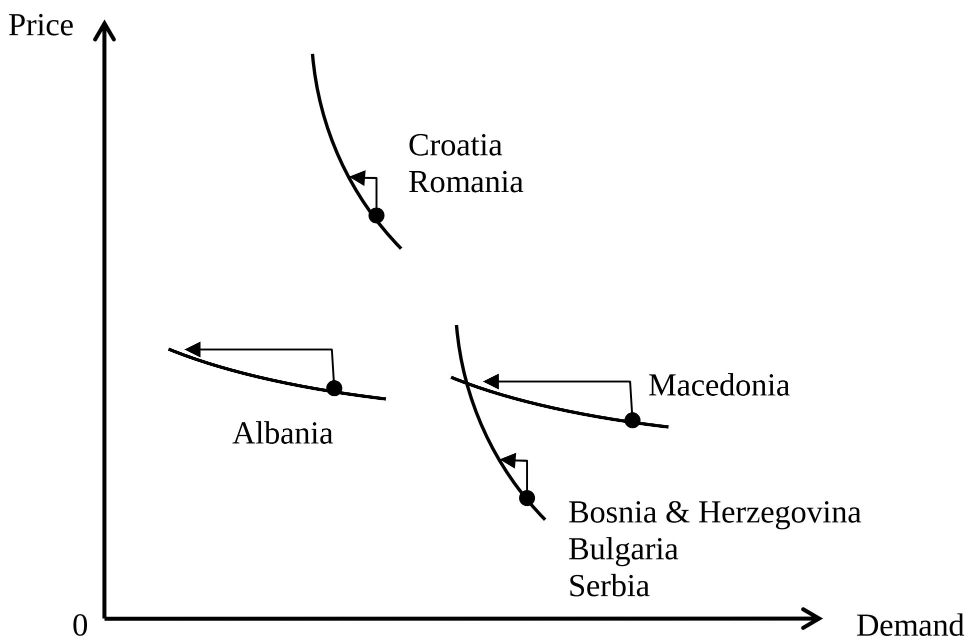
[41] For instance, Romania has a much low price elasticity of –0.21; thus, one cannot expect that any negative supply shock would induce firms to reduce energy consumption. They would keep consume energy as they are doing. Accordingly, the domestic energy market would come under enormous upward price pressure. But Romania's nonresidential electricity price, for example, reached 12.5 U.S. cents per kWh. In this regard, the past history of price adjustments reflected in Figure 6 seems to have been consistent with the paper's estimation result.

[42] For instance, IEA (2008) calls for further end-use price adjustments to finalize full cost-recovery in Bosnia and Herzegovina, and Serbia. Our analysis implies that pricing may not be the only solution but should be combined with other incentive measures. The difference in policy emphasis is attributable to the difference in methodology and scope of analysis. This paper focuses on micro behavior and analyzes the nonresidential energy market, while most of the earlier documents discussed a wider range of issues at the country level. Although the claims are not necessarily contradictory, it is noteworthy that direct policy implications could appear different.

improve firm efficiency furthermore, for example, through improving energy efficiency and infrastructure qualities. Filippini and Hunt (2009) discuss energy efficiency in OECD member countries under the SFA framework. Our paper has been shown that small and/or labor-intensive enterprises have more room to improve technical efficiency.

If the estimated results are interpreted straightforwardly, Bosnia and Herzegovina, Bulgaria and Serbia may be able to rely on pricing, but only to a certain extent. In these countries, some room for price increases may remain. However, the expected demand response are weak and thus, they may be faced with the same risk as Croatia and Romania. According to our estimation results, a risk of damaging the real economy may not be large in Serbia, because of its low cost elasticity with respect to energy prices. But the risk may remain high in Bosnia and Herzegovina, and Bulgaria where the cost elasticity is high (Figure 17). Without doubt, there is room for technical efficiency improvement. Bulgaria is estimated to have the lowest technical efficacy in the region. The average technical efficiency of Bosnia and Herzegovina is also 80 percent lower than Croatia.

Figure 19. Estimated price-demand relationship in SEE countries given an energy crisis



Source: Author’s illustration.

Predicted demand response to global economic downturns

There are two possible consequences of a worldwide slowdown in economic activity.[43] First, it can reduce the general demand for energy and thus improve the global energy balance. International energy prices would decline. Therefore, energy-scarce countries could purchase electricity or fuel sources for domestic power generation at relatively low costs and might be able to have excess supply of energy. If governments translate this favorable market condition into their domestic energy tariffs, the demand for energy would increase. This may be particularly relevant to Macedonia where the energy-intensive industries are significant in production and exports. In the rest of the SEE countries, the firms' response on the real side would be limited. But the downward pressure on domestic energy prices would be large if the shock is accommodated (Figure 20).

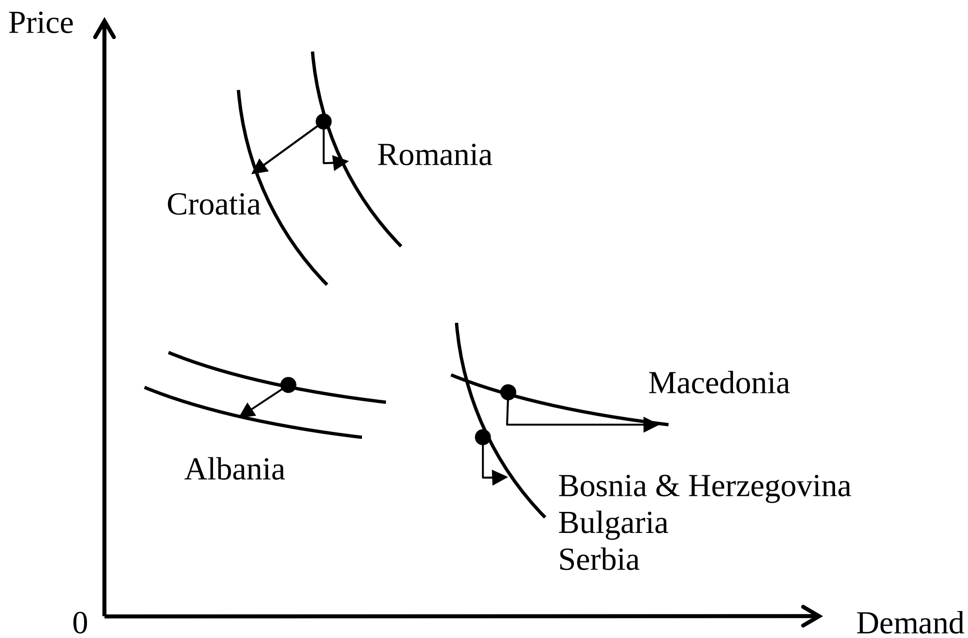
Second, however, there is another consequence for the demand for products, especially for material industries. Albania and Croatia, where the conditional energy demand elasticities with respect to output are estimated to be high, would experience large reductions in the nonresidential demand for energy, given the global economic downturn. On the other hand, let us assume that the energy demand elasticities would be negligible in the rest of countries. In Albania, the expected impact of reduced energy tariffs would be potentially large, but the effect might be offset by an energy demand shift caused by demand reduction in products. In Croatia, the pricing effect is expected to be small, but the country may experience a large reduction in energy demand because of the economic stagnation.

How the authorities should react to these expected consequences is out of the scope of the current paper. But the paper provides some insight on what they could do. The expected reduction in energy demand may create some room to carry out other energy policies for

[43] An important implicit assumption underlying this argument is that the demand response to output would be symmetric and marginal. Since our models are mainly estimated with the 2005 data, it is not necessarily clear whether it would be appropriate to interpret the results in the context of the current global economic downturn since 2008. The demand response could be asymmetrically rigid or elastic, and given a significant slowdown, the cost structure might change. The discussion here is valid as long as a marginal shock in output is considered.

balancing energy supply and demand. The regional energy trading and infrastructure integration, as intended in the SEE region, could contribute to expanding policy options and improving energy security and invulnerability to external shocks among the regional countries. Countries with the price-elastic energy demand would likely benefit from the reduced energy (import) prices.

Figure 20. Estimated price-demand relationship in SEE countries given an economic crisis



Source: Author’s illustration.

VII. Conclusion

The world economy has experienced significant hicks and uncertainties in international energy prices since 2000. A series of increases in energy prices reveal that South Eastern Europe is one of the vulnerable regions to such external energy shocks.

The paper recasts light on the relationship between the price of and the demand for energy in the SEE countries. By estimating the price elasticity of demand, it examines to what extent demand would be affected by changes in energy prices. The price-demand relationship is essential in designing and implementing some price and/or supply adjustments.

Although there are a number of empirical and data issues, the evidence tentatively shows that the price elasticity of industrial energy demand is about –0.4 on average. But it may vary significantly depending on the country; Albania and Macedonia are estimated to have a highly elastic demand. The elasticity seems to be on the order of–0.7 to –0.8. For the rest of the SEE countries, the elasticities appear relatively low at –0.2 to –0.4. Therefore, in Albania and Macedonia, price adjustments would be one of the effective policy options to balance demand with supply, while strengthening the financial viability and sustainability of the energy sector. In other countries, the demand response would be weak. Hence, other policy measures, such as facilitation of energy efficiency at the firm level and improvements in the quality of public infrastructure services, may also be required to address the energy-sector issues.

In addition, it is shown that the energy demand structure in some countries would be very responsive to the general economic trend. The conditional energy demand elasticity with respect to output is estimated at 0.08 to 0.17 in the region. But the elasticity is relatively high in two countries: Albania and Croatia. In these countries, energy demand may decline in spite of favorable energy input prices. This is because energy demand is also affected by output demand and the pricing effect may be partly offset by the real impact of the global economic downturn.

APPENDIX

Table A1. Estimated cost function without data from Albania

	SUR		SFA	
	Excluding Albania		Excluding Albania	
βY	0.8670	(0.0269) ***	0.8634	(0.0325) ***
βYY	0.0045	(0.0040)	0.0010	(0.0041)
βW_L	0.5900	(0.0164) ***	0.8046	(0.0332) ***
βW_E	0.1079	(0.0179) ***	–0.0216	(0.0616)
$\beta W_L W_L$	–0.0043	(0.0061)	–0.1375	(0.0222) ***
$\beta W_L W_E$	0.1262	(0.0031) ***	0.2222	(0.0101) ***
$\beta W_L W_K$	–0.1316	(0.0036) ***	–0.1628	(0.0130) ***
$\beta W_E W_E$	0.0738	(0.0040) ***	0.0523	(0.0166) ***
$\beta W_E W_K$	0.0092	(0.0040) **	0.0174	(0.0136)
βYW_L	0.0036	(0.0023)	0.0112	(0.0033) ***
βYW_E	–0.0193	(0.0026) ***	–0.0363	(0.0071) ***
βZ_{P1}	0.0017	(0.0022)	0.0012	(0.0018)
βZ_{P2}	0.0134	(0.0085)	0.0161	(0.0092) *
$\beta Z_{P1} Z_{P1}$	4.0E-06	(1.7E-05)	6.0E-06	(1.4E-05)
$\beta Z_{P1} Z_{P2}$	–5.1E-05	(1.3E-04)	–3.0E-05	(6.8E-05)
$\beta Z_{P2} Z_{P2}$	4.0E-04	(5.6E-04)	8.9E-05	(4.2E-04)
βYZ_{P1}	–1.5E-05	(3.8E-04)	4.3E-06	(3.7E-04)
βYZ_{P2}	–6.3E-04	(1.1E-03)	6.4E-04	(9.5E-04)
$\beta W_L Z_{P1}$	1.4E-04	(2.4E-04)	5.7E-05	(2.5E-04)
$\beta W_L Z_{P2}$	–1.2E-03	(1.0E-03)	–1.6E-03	(1.1E-03)
$\beta W_E Z_{P1}$	3.9E-04	(2.6E-04)	5.7E-04	(8.3E-04)
$\beta W_E Z_{P2}$	2.0E-03	(1.4E-03)	5.5E-03	(3.0E-03) *
Construction	0.0331	(0.0658)	0.0659	(0.0581)
Manufacturing	0.0976	(0.0615)	0.1262	(0.0522) **
Transport	–0.0504	(0.0674)	0.1167	(0.0712) *
Trade	0.0350	(0.0633)	0.0969	(0.0544) *
Real estate	–0.0625	(0.0674)	–0.0142	(0.0616)
Restaurant & hotel	0.0360	(0.0677)	0.0724	(0.0672)
Other services	–0.0195	(0.0708)	0.0607	(0.0689)
Constant	–0.3463	(0.1171) ***	–0.5359	(0.1698) ***
Obs.	872		872	
Chi-square				
Cost equation	72735.2		87047.6	
Wage share equation	1972.6			
Energy cost share equat	8286.6			

Note that the dependent variable is the logarithmic operating cost. The standard errors are shown in parentheses. *, ** and *** represent the 10%, 5% and 1% level significance, respectively.

Table A2. Estimated cost function: Macedonia

	SUR		SFA	
	Macedonia		Macedonia	
β_{Y}	0.8307	(0.1013) ***	0.9039	(0.0886) ***
β_{YY}	0.0234	(0.0150)	0.0174	(0.0151)
β_{W_L}	0.8546	(0.0602) ***	1.0472	(0.1032) ***
β_{W_E}	–0.3004	(0.0471) ***	–0.5338	(0.0863) ***
$\beta_{W_L W_L}$	–0.0549	(0.0248) **	–0.1022	(0.0738)
$\beta_{W_L W_E}$	0.1701	(0.0086) ***	0.2212	(0.0133) ***
$\beta_{W_L W_K}$	–0.1590	(0.0131) ***	–0.1695	(0.0396) ***
$\beta_{W_E W_E}$	0.0146	(0.0096)	–0.0148	(0.0260)
$\beta_{W_E W_K}$	0.0172	(0.0106) *	0.0112	(0.0252)
β_{YW_L}	0.0069	(0.0077)	0.0060	(0.0092)
β_{YW_E}	0.0055	(0.0068)	0.0139	(0.0138)
$\beta_{Z_{P1}}$	0.0377	(0.0297) **	0.0447	(0.0240) *
$\beta_{Z_{P2}}$	–0.1441	(0.0678)	–0.1280	(0.0375) ***
$\beta_{Z_{P1}Z_{P1}}$	0.0002	(0.0002)	0.0005	(0.0001) ***
$\beta_{Z_{P1}Z_{P2}}$	–0.0036	(0.0083)	–0.0093	(0.0059)
$\beta_{Z_{P2}Z_{P2}}$	–0.0328	(0.0161) **	–0.0364	(0.0096) ***
$\beta_{YZ_{P1}}$	–0.0073	(0.0044) *	0.0021	(0.0030)
$\beta_{YZ_{P2}}$	0.0403	(0.0170) **	0.0347	(0.0156) **
$\beta_{W_L Z_{P1}}$	0.0014	(0.0009)	0.0009	(0.0018)
$\beta_{W_L Z_{P2}}$	–0.0025	(0.0074)	–0.0055	(0.0086)
$\beta_{W_E Z_{P1}}$	0.0001	(0.0006)	0.0233	(0.0074) ***
$\beta_{W_E Z_{P2}}$	–0.0033	(0.0072)	–0.0168	(0.0155)
Construction	–0.1038	(0.1910)	–0.2256	(0.1067) **
Manufacturing	–0.0034	(0.1909)	–0.1878	(0.1093) *
Transport	–0.2645	(0.2104)	–0.5503	(0.1838) ***
Trade	–0.0450	(0.1934)	–0.2553	(0.1057) **
Real estate	–0.0407	(0.2127)	–0.0754	(0.1477)
Restaurant & hotel	–0.2095	(0.2073)	–0.3000	(0.1392) **
Other services	–0.1970	(0.2259)	–0.1137	(0.1309)
Constant	–1.1143	(0.3689) ***	–1.7041	(0.3007) ***
Obs.	89		89	
Chi-square				
Cost equation	14591.1		519288.9	
Wage share equation	419.8			
Energy cost share equation	918.0			

Note that the dependent variable is the logarithmic operating cost. The standard errors are shown in parentheses. *, ** and *** represent the 10%, 5% and 1% level significance, respectively.

Table A3. Estimated cost function: Serbia

	SUR			SFA		
	Serbia & Montenegro			Serbia & Montenegro		
βY	1.0222	(0.0453)	***	1.0256	(0.0458)	***
βYY	−0.0040	(0.0066)		−0.0003	(0.0053)	
βW_L	0.8951	(0.0386)	***	1.2059	(0.0604)	***
βW_E	−0.2115	(0.0371)	***	−0.6031	(0.0874)	***
$\beta W_L W_L$	−0.0694	(0.0196)	***	−0.2494	(0.0528)	***
$\beta W_L W_E$	0.2027	(0.0084)	***	0.3097	(0.0215)	***
$\beta W_L W_K$	−0.1789	(0.0104)	***	−0.1972	(0.0302)	***
$\beta W_E W_E$	0.0460	(0.0100)	***	0.0026	(0.0158)	
$\beta W_E W_K$	−0.0039	(0.0092)		0.0145	(0.0184)	
βYW_L	0.0001	(0.0041)		−0.0060	(0.0035)	*
βYW_E	−0.0021	(0.0048)		0.0102	(0.0118)	
βZ_{P1}	0.0082	(0.0100)		−0.0033	(0.0068)	
βZ_{P2}	0.0035	(0.0161)		0.0098	(0.0106)	
$\beta Z_{P1} Z_{P1}$	1.8E-05	(1.6E-04)		9.3E-05	(1.3E-04)	
$\beta Z_{P1} Z_{P2}$	−3.3E-05	(9.1E-04)		1.5E-04	(7.3E-04)	
$\beta Z_{P2} Z_{P2}$	6.8E-04	(9.2E-04)		3.9E-04	(6.0E-04)	
βYZ_{P1}	−5.1E-04	(9.4E-04)		4.7E-04	(7.5E-04)	
βYZ_{P2}	−7.8E-04	(2.0E-03)		−1.3E-04	(1.9E-03)	
$\beta W_L Z_{P1}$	−9.8E-04	(8.9E-04)		−1.4E-03	(9.0E-04)	
$\beta W_L Z_{P2}$	−7.8E-04	(2.2E-03)		−3.2E-04	(1.5E-03)	
$\beta W_E Z_{P1}$	1.2E-03	(8.0E-04)		6.5E-04	(1.2E-03)	
$\beta W_E Z_{P2}$	1.1E-03	(2.3E-03)		4.1E-03	(6.4E-03)	
Construction	0.1052	(0.0874)		0.0460	(0.0595)	
Manufacturing	0.0903	(0.0830)		−0.0077	(0.0587)	
Transport	0.0228	(0.0925)		0.0218	(0.0631)	
Trade	0.1092	(0.0856)		0.0201	(0.0615)	
Real estate	0.0769	(0.0902)		0.0218	(0.0596)	
Restaurant & hotel	−0.0138	(0.0895)		−0.0227	(0.0725)	
Other services	0.0313	(0.0911)		−0.0068	(0.0635)	
Constant	−1.5933	(0.1856)	***	−1.9388	(0.2532)	***
Obs.	122			122		
Chi-square						
Cost equation	35033.4			110989.2		
Wage share equation	715.3					
Energy cost share equat	2136.7					

Note that the dependent variable is the logarithmic operating cost. The standard errors are shown in parentheses. *, ** and *** represent the 10%, 5% and 1% level significance, respectively.

Table A4. Estimated cost function: Croatia

	SUR			SFA		
	Croatia			Croatia		
β_Y	0.9975	(0.0468)	***	1.0305	(0.0390)	***
β_{YY}	–0.0009	(0.0058)		–0.0057	(0.0048)	
β_{W_L}	0.8792	(0.0414)	***	1.1539	(0.0697)	***
β_{W_E}	–0.1848	(0.0365)	***	–0.5728	(0.0663)	***
$\beta_{W_L W_L}$	–0.0910	(0.0131)	***	–0.1900	(0.0538)	***
$\beta_{W_L W_E}$	0.1625	(0.0064)	***	0.2849	(0.0227)	***
$\beta_{W_L W_K}$	–0.1241	(0.0087)	***	–0.1895	(0.0423)	***
$\beta_{W_E W_E}$	0.0666	(0.0068)	***	0.0296	(0.0130)	**
$\beta_{W_E W_K}$	–0.0211	(0.0060)	***	–0.0167	(0.0120)	
β_{YW_L}	0.0022	(0.0043)		0.0020	(0.0055)	
β_{YW_E}	4.8E-05	(4.0E-03)		–4.4E-03	(6.8E-03)	
$\beta_{Z_{P1}}$	4.1E-03	(1.2E-02)		2.3E-02	(8.6E-03)	***
$\beta_{Z_{P2}}$	1.6E-02	(1.4E-02)		1.2E-02	(1.0E-02)	
$\beta_{Z_{P1} Z_{P1}}$	2.2E-05	(3.0E-04)		–2.0E-04	(2.2E-04)	
$\beta_{Z_{P1} Z_{P2}}$	–1.7E-04	(5.6E-04)		–6.4E-04	(3.7E-04)	*
$\beta_{Z_{P2} Z_{P2}}$	1.9E-03	(1.2E-03)	*	2.2E-03	(1.0E-03)	**
$\beta_{YZ_{P1}}$	–6.0E-05	(1.7E-03)		–5.1E-03	(2.5E-03)	**
$\beta_{YZ_{P2}}$	–1.1E-03	(1.8E-03)		6.3E-04	(1.8E-03)	
$\beta_{W_L Z_{P1}}$	4.7E-04	(1.6E-03)		6.0E-03	(2.9E-03)	**
$\beta_{W_L Z_{P2}}$	–3.6E-03	(2.6E-03)		–5.3E-03	(3.1E-03)	*
$\beta_{W_E Z_{P1}}$	4.3E-04	(1.3E-03)		–4.0E-03	(2.8E-03)	
$\beta_{W_E Z_{P2}}$	3.6E-03	(2.0E-03)		7.4E-03	(3.7E-03)	**
Construction	–0.0433	(0.0761)		–0.0028	(0.0424)	
Manufacturing	0.0142	(0.0694)		0.0607	(0.0362)	*
Transport	–0.1847	(0.0781)	**	0.0234	(0.0519)	
Trade	–0.0183	(0.0719)		0.0020	(0.0433)	
Real estate	–0.0513	(0.0750)		0.0133	(0.0444)	
Restaurant & hotel	0.0926	(0.0841)		0.0813	(0.0475)	*
Other services	–0.0131	(0.1237)		0.1120	(0.1027)	
Constant	–1.7065	(0.2311)	***	–2.3841	(0.2056)	***
Obs.	172			172		
Chi-square						
Cost equation	44382.0			158997.3		
Wage share equation	822.7					
Energy cost share equation	2002.1					

Note that the dependent variable is the logarithmic operating cost. The standard errors are shown in parentheses. *, ** and *** represent the 10%, 5% and 1% level significance, respectively.

Table A5. Estimated cost function: Bosnia and Herzegovina

	SUR		SFA	
	Bosnia & Herzegovina		Bosnia & Herzegovina	
β_Y	0.8420	(0.1089) ***	0.9498	(0.1235) ***
β_{YY}	0.0155	(0.0164)	0.0046	(0.0234)
β_{W_L}	0.7177	(0.0615) ***	0.9151	(0.0669) ***
β_{W_E}	–0.0150	(0.0569)	–0.2476	(0.1545) *
$\beta_{W_L W_L}$	–0.0493	(0.0222) **	–0.1704	(0.0662) ***
$\beta_{W_L W_E}$	0.1532	(0.0102) ***	0.2767	(0.0371) ***
$\beta_{W_L W_K}$	–0.1476	(0.0122) ***	–0.2085	(0.0470) ***
$\beta_{W_E W_E}$	0.0775	(0.0109) ***	0.1039	(0.0334) ***
$\beta_{W_E W_K}$	–0.0080	(0.0102)	–0.0300	(0.0282)
β_{YW_L}	0.0058	(0.0083)	0.0038	(0.0123)
β_{YW_E}	–0.0127	(0.0078) *	–0.0079	(0.0226)
$\beta_{Z_{P1}}$	0.0475	(0.0417)	0.0451	(0.0395)
$\beta_{Z_{P2}}$	0.0044	(0.1060)	–0.0241	(0.1441)
$\beta_{Z_{P1} Z_{P1}}$	–0.0053	(0.0031) *	–0.0028	(0.0030)
$\beta_{Z_{P1} Z_{P2}}$	0.0045	(0.0028)	0.0032	(0.0022)
$\beta_{Z_{P2} Z_{P2}}$	0.0007	(0.0027)	0.0030	(0.0023)
$\beta_{YZ_{P1}}$	–0.0034	(0.0053)	–0.0060	(0.0044)
$\beta_{YZ_{P2}}$	0.0006	(0.0145)	0.0129	(0.0151)
$\beta_{W_L Z_{P1}}$	–0.0013	(0.0028)	0.0015	(0.0031)
$\beta_{W_L Z_{P2}}$	0.0016	(0.0064)	–0.0018	(0.0156)
$\beta_{W_E Z_{P1}}$	–0.0010	(0.0031)	–0.0040	(0.0073)
$\beta_{W_E Z_{P2}}$	0.0055	(0.0047)	0.0259	(0.0324)
Construction	0.4263	(0.1977) **	0.4147	(0.2630)
Manufacturing	0.2541	(0.1868)	0.2655	(0.2281)
Transport	0.3689	(0.1942) *	0.3132	(0.2434)
Trade	0.3642	(0.1938) *	0.3089	(0.2603)
Real estate	0.1973	(0.2104)	0.1672	(0.2379)
Restaurant & hotel	0.2660	(0.1902)	0.2872	(0.2377)
Other services	0.3171	(0.2019)	0.3144	(0.2383)
Constant	–1.0275	(0.3767) ***	–1.5137	(0.3968) ***
Obs.	79		79	
Chi-square				
Cost equation	10019.0		...	
Wage share equation	351.2			
Energy cost share equation	897.6			

Note that the dependent variable is the logarithmic operating cost. The standard errors are shown in parentheses. *, ** and *** represent the 10%, 5% and 1% level significance, respectively.

Table A6. Estimated cost function: Romania

	SUR Romania		SFA Romania	
β_{Y}	0.7454	(0.0537) ***	0.7371	(0.0698) ***
β_{YY}	0.0132	(0.0080) *	0.0099	(0.0098)
β_{W_L}	0.4952	(0.0336) ***	0.6455	(0.0825) ***
β_{W_E}	0.3364	(0.0333) ***	0.2021	(0.1139) *
$\beta_{W_L W_L}$	0.0323	(0.0137) **	–0.0878	(0.0431) **
$\beta_{W_L W_E}$	0.1338	(0.0065) ***	0.2624	(0.0194) ***
$\beta_{W_L W_K}$	–0.1449	(0.0079) ***	–0.2257	(0.0235) ***
$\beta_{W_E W_E}$	0.0785	(0.0079) ***	0.0150	(0.0260)
$\beta_{W_E W_K}$	0.0224	(0.0074) ***	0.0672	(0.0172) ***
β_{YW_L}	0.0095	(0.0051) *	0.0238	(0.0084) ***
β_{YW_E}	–0.0404	(0.0049) ***	–0.0699	(0.0114) ***
$\beta_{Z_{P1}}$	0.0006	(0.0040)	0.0019	(0.0021)
$\beta_{Z_{P2}}$	–0.0273	(0.0222)	–0.0096	(0.0261)
$\beta_{Z_{P1} Z_{P1}}$	–3.7E-05	(2.9E-05)	–3.0E-05	(3.6E-05)
$\beta_{Z_{P1} Z_{P2}}$	–1.5E-04	(1.5E-04)	–2.3E-05	(1.1E-04)
$\beta_{Z_{P2} Z_{P2}}$	2.2E-03	(1.0E-03) **	1.5E-03	(9.2E-04) *
$\beta_{YZ_{P1}}$	1.5E-04	(6.2E-04)	–9.6E-05	(5.1E-04)
$\beta_{YZ_{P2}}$	1.6E-03	(3.0E-03)	3.6E-04	(3.4E-03)
$\beta_{W_L Z_{P1}}$	2.6E-04	(5.6E-04)	1.1E-03	(8.2E-04)
$\beta_{W_L Z_{P2}}$	–3.1E-03	(2.3E-03)	–4.5E-03	(3.5E-03)
$\beta_{W_E Z_{P1}}$	1.7E-05	(4.9E-04)	1.4E-04	(1.5E-03)
$\beta_{W_E Z_{P2}}$	–7.7E-04	(2.2E-03)	1.6E-03	(3.9E-03)
Construction	–0.0931	(0.0763)	–0.1046	(0.1108)
Manufacturing	0.0056	(0.0659)	–0.0431	(0.1070)
Transport	0.0179	(0.0869)	0.0529	(0.1345)
Trade	0.0222	(0.0705)	–0.0214	(0.1043)
Real estate				
Restaurant & hotel	–0.0214	(0.0845)	–0.0800	(0.1179)
Other services	–0.0406	(0.0826)	0.0326	(0.1111)
Constant	0.7740	(0.1975) ***	0.5522	(0.3232) *
Obs.	269		269	
Chi-square				
Cost equation	274589.3		25536.8	
Wage share equation	491.2			
Energy cost share equation	2267.5			

Note that the dependent variable is the logarithmic operating cost. The standard errors are shown in parentheses. *, ** and *** represent the 10%, 5% and 1% level significance, respectively.

Table A7. Estimated cost function: Bulgaria

	SUR		SFA	
	Bulgaria		Bulgaria	
β_Y	0.9272	(0.0656) ***	0.8904	(0.0524) ***
β_{YY}	–0.0033	(0.0105)	–0.0002	(0.0112)
β_{W_L}	0.6661	(0.0454) ***	0.9846	(0.0521) ***
β_{W_E}	0.1397	(0.0339) ***	0.0447	(0.0733)
$\beta_{W_L W_L}$	0.0744	(0.0241) ***	–0.1666	(0.0680) **
$\beta_{W_L W_E}$	0.1348	(0.0083) ***	0.2609	(0.0145) ***
$\beta_{W_L W_K}$	–0.1373	(0.0120) ***	–0.1829	(0.0305) ***
$\beta_{W_E W_E}$	0.0747	(0.0070) ***	0.0544	(0.0208) ***
$\beta_{W_E W_K}$	–0.0204	(0.0082) **	–0.0124	(0.0293)
β_{YW_L}	–0.0135	(0.0078) *	–0.0007	(0.0093)
β_{YW_E}	–0.0121	(0.0056) **	–0.0334	(0.0150) **
$\beta_{Z_{P1}}$	0.0030	(0.0035)	–0.0009	(0.0039)
$\beta_{Z_{P2}}$	–0.0136	(0.0410)	0.0561	(0.0376)
$\beta_{Z_{P1}Z_{P1}}$	2.4E-04	(6.4E-05) ***	2.7E-04	(1.2E-04) **
$\beta_{Z_{P1}Z_{P2}}$	1.3E-03	(5.6E-04) **	1.8E-03	(8.2E-04) **
$\beta_{Z_{P2}Z_{P2}}$	–2.2E-03	(2.7E-03)	–3.3E-03	(2.0E-03) *
$\beta_{YZ_{P1}}$	–4.2E-03	(1.2E-03) ***	–8.8E-03	(3.9E-03) **
$\beta_{YZ_{P2}}$	4.9E-03	(5.6E-03)	3.6E-03	(4.0E-03)
$\beta_{W_L Z_{P1}}$	–7.3E-05	(4.8E-04)	–1.4E-03	(9.4E-04)
$\beta_{W_L Z_{P2}}$	–3.3E-03	(4.8E-03)	–9.5E-03	(6.4E-03)
$\beta_{W_E Z_{P1}}$	–1.3E-04	(3.0E-04)	–1.1E-02	(5.7E-03) **
$\beta_{W_E Z_{P2}}$	–3.1E-03	(3.7E-03)	2.4E-02	(1.1E-02) **
Construction	–0.2253	(0.1529)	–0.0173	(0.0998)
Manufacturing	–0.1710	(0.1385)	–0.0601	(0.0807)
Transport	–0.5014	(0.1472) ***	–0.0611	(0.0976)
Trade	–0.2901	(0.1447) **	–0.0820	(0.0904)
Real estate	–0.3546	(0.1513) **	–0.2385	(0.0904) ***
Restaurant & hotel	–0.1052	(0.1524)	0.0540	(0.0974)
Other services	–0.3158	(0.1574) **	–0.1180	(0.0995)
Constant	–0.0062	(0.2531)	–0.1832	(0.1795)
Obs.	141		141	
Chi-square				
Cost equation	11206.3		85146.5	
Wage share equation	351.1			
Energy cost share equation	672.2			

Note that the dependent variable is the logarithmic operating cost. The standard errors are shown in parentheses. *, ** and *** represent the 10%, 5% and 1% level significance, respectively.

Table A8. Estimated cost function: Albania

	SUR	
	Albania	
β_{Y}	1.0954	(0.0823) ***
β_{YY}	–0.0098	(0.0106)
β_{W_L}	1.0030	(0.0508) ***
β_{W_E}	–0.2873	(0.0587) ***
$\beta_{W_L W_L}$	–0.0517	(0.0182) ***
$\beta_{W_L W_E}$	0.2110	(0.0092) ***
$\beta_{W_L W_K}$	–0.1817	(0.0116) ***
$\beta_{W_E W_E}$	0.0124	(0.0114)
$\beta_{W_E W_K}$	0.0191	(0.0112) *
β_{YW_L}	–0.0125	(0.0061) **
β_{YW_E}	0.0022	(0.0073)
$\beta_{Z_{P1}}$	0.0013	(0.0007) *
$\beta_{Z_{P2}}$	0.0168	(0.0487)
$\beta_{Z_{P1} Z_{P1}}$	–3.5E-06	(2.6E-06)
$\beta_{Z_{P1} Z_{P2}}$	6.7E-06	(5.6E-05)
$\beta_{Z_{P2} Z_{P2}}$	4.6E-03	(4.8E-03)
$\beta_{Y Z_{P1}}$	–1.1E-04	(7.7E-05)
$\beta_{Y Z_{P2}}$	–1.8E-03	(5.9E-03)
$\beta_{W_L Z_{P1}}$	–8.6E-05	(6.4E-05)
$\beta_{W_L Z_{P2}}$	–5.7E-03	(4.2E-03)
$\beta_{W_E Z_{P1}}$	–6.1E-05	(7.2E-05)
$\beta_{W_E Z_{P2}}$	9.7E-03	(4.9E-03) **
Construction	–0.1088	(0.1139)
Manufacturing	–0.0847	(0.1102)
Transport	–0.2112	(0.1163) *
Trade	–0.1417	(0.1125)
Real estate	–0.2287	(0.1351) *
Restaurant & hotel	–0.2476	(0.1157) **
Other services	–0.3288	(0.1287) **
Constant	–1.6647	(0.3631) ***
Obs.	118	
Chi-square		
Cost equation	20129.7	
Wage share equation	543.2	
Energy cost share equation	1206.6	

Note that the dependent variable is the logarithmic operating cost. The standard errors are shown in parentheses. *, ** and *** represent the 10%, 5% and 1% level significance, respectively.

Table A9. Estimated cost functions by SUR with unbalanced panel data

	SUR All		SUR Albania		SUR Bosnia & Herzegovina		SUR Bulgaria		SUR Croatia		SUR Macedonia		SUR Romania		SUR Serbia	
β_{Y}	0.9254	(0.0693) ***	1.1788	(0.2510) ***	0.5825	(0.2285) **	0.6896	(0.1281) ***	0.9932	(0.1070) ***	0.2217	(0.3343)	1.0036	(0.1920) ***	1.0983	(0.1605) ***
β_{YY}	–0.0001	(0.0048)	–0.0057	(0.0164)	0.0172	(0.0151)	0.0175	(0.0090) *	0.0013	(0.0066)	0.0477	(0.0240) **	–0.0111	(0.0135)	–0.0107	(0.0110)
β_{W_L}	0.7012	(0.0395) ***	1.3564	(0.1315) ***	0.6504	(0.1222) ***	0.9675	(0.0961) ***	1.1672	(0.0812) ***	0.8231	(0.1557) ***	0.1964	(0.1045) *	0.5699	(0.0945) ***
β_{W_E}	–0.1294	(0.0353) ***	–0.3614	(0.1395) ***	–0.4286	(0.1030) ***	–0.1769	(0.0719) **	–0.7391	(0.0806) ***	–0.4730	(0.1435) ***	0.0435	(0.0794)	–0.1986	(0.0875) **
$\beta_{W_L W_L}$	–0.0332	(0.0032) ***	–0.0838	(0.0089) ***	–0.0502	(0.0092) ***	–0.0906	(0.0086) ***	–0.0696	(0.0063) ***	–0.0487	(0.0117) ***	0.0130	(0.0080) *	–0.0087	(0.0073)
$\beta_{W_L W_E}$	0.0542	(0.0033) ***	0.0798	(0.0107) ***	0.0792	(0.0094) ***	0.0559	(0.0079) ***	0.1015	(0.0070) ***	0.0843	(0.0114) ***	0.0476	(0.0077) ***	0.0489	(0.0088) ***
$\beta_{W_L W_K}$	–0.0735	(0.0037) ***	–0.0434	(0.0120) ***	–0.0821	(0.0107) ***	–0.0493	(0.0098) ***	–0.0704	(0.0082) ***	–0.0810	(0.0131) ***	–0.1106	(0.0081) ***	–0.0940	(0.0089) ***
$\beta_{W_E W_E}$	0.0715	(0.0033) ***	0.0511	(0.0100) ***	0.0589	(0.0080) ***	0.0733	(0.0056) ***	0.0651	(0.0063) ***	0.0498	(0.0109) ***	0.0697	(0.0073) ***	0.0659	(0.0089) ***
$\beta_{W_E W_K}$	–0.0368	(0.0030) ***	–0.0109	(0.0081)	–0.0407	(0.0069) ***	–0.0607	(0.0061) ***	–0.0338	(0.0055) ***	–0.0284	(0.0104) ***	–0.0218	(0.0065) ***	–0.0504	(0.0075) ***
β_{YW_L}	0.0002	(0.0023)	–0.0125	(0.0073) *	0.0188	(0.0070) ***	0.0093	(0.0058)	–0.0022	(0.0042)	0.0084	(0.0092)	0.0086	(0.0059)	–0.0021	(0.0051)
β_{YW_E}	–0.0071	(0.0021) ***	–0.0100	(0.0081)	–0.0035	(0.0054)	–0.0003	(0.0041)	0.0014	(0.0036)	–0.0063	(0.0082)	–0.0153	(0.0047) ***	0.0006	(0.0044)
$\beta_{Z_{P1}}$	0.0061	(0.0012) ***	0.0041	(0.0020) **	–0.0186	(0.0069) ***	0.0065	(0.0043)	0.0333	(0.0213)	–0.0142	(0.0183)	0.0165	(0.0037) ***	0.0284	(0.0087) ***
$\beta_{Z_{P2}}$	0.0207	(0.0214)	0.1538	(0.1264)	–0.1742	(0.1356)	0.0609	(0.0789)	–0.0025	(0.0300)	0.3007	(0.2262)	0.1040	(0.0510) **	–0.1046	(0.0712)
$\beta_{Z_{P1}Z_{P1}}$	0.0000	(0.0000) *	0.0000	(0.0000)	0.0000	(0.0000) ***	0.0000	(0.0000) ***	–0.0000	(0.0000)	0.0001	(0.0001)	–0.0000	(0.0000)	–0.0000	(0.0000) ***
$\beta_{Z_{P1}Z_{P2}}$	–0.0002	(0.0000) ***	–0.0001	(0.0001)	–0.0015	(0.0007) **	0.0003	(0.0003)	–0.0018	(0.0004) ***	0.0044	(0.0018) **	–0.0003	(0.0001) ***	0.0000	(0.0003)
$\beta_{Z_{P2}Z_{P2}}$	–0.0000	(0.0000)	0.0026	(0.0072)	–0.0033	(0.0014) **	–0.0020	(0.0025)	0.0021	(0.0011) *	–0.0045	(0.0159)	0.0000	(0.0001)	0.0046	(0.0019) **
$\beta_{YZ_{P1}}$	–0.0004	(0.0001) ***	–0.0003	(0.0001) **	0.0003	(0.0004)	–0.0005	(0.0002) **	–0.0033	(0.0015) **	0.0004	(0.0009)	–0.0011	(0.0002) ***	–0.0018	(0.0006) ***
$\beta_{YZ_{P2}}$	–0.0012	(0.0015)	–0.0082	(0.0082)	0.0113	(0.0104)	–0.0064	(0.0052)	0.0000	(0.0019)	–0.0187	(0.0166)	–0.0089	(0.0039) ***	0.0030	(0.0047)
$\beta_{W_L Z_{P1}}$	–0.0002	(0.0000) ***	–0.0001	(0.0001) *	0.0008	(0.0003) ***	–0.0004	(0.0002)	0.0012	(0.0004) ***	–0.0006	(0.0005)	0.0000	(0.0002)	–0.0001	(0.0002)
$\beta_{W_L Z_{P2}}$	0.0000	(0.0007)	–0.0065	(0.0053)	0.0100	(0.0031) ***	0.0036	(0.0041)	–0.0006	(0.0022)	–0.0044	(0.0085)	0.0003	(0.0008)	0.0022	(0.0031)
$\beta_{W_E Z_{P1}}$	–0.0000	(0.0000)	–0.0001	(0.0001)	0.0001	(0.0001)	0.0001	(0.0001)	–0.0008	(0.0003) ***	0.0007	(0.0004) *	0.0001	(0.0001)	0.0003	(0.0002)
$\beta_{W_E Z_{P2}}$	0.0003	(0.0005)	–0.0001	(0.0058)	–0.0007	(0.0023)	–0.0034	(0.0028)	0.0007	(0.0016)	0.0007	(0.0083)	0.0003	(0.0005)	0.0008	(0.0022)
Constant	–3.6748	(0.5475) ***	–8.6944	(2.0752) ***	–1.7627	(1.8312)	–3.6681	(1.0162) ***	–7.4042	(1.0011) ***	–0.3075	(2.4401)	–2.0012	(1.4581)	–4.8233	(1.3095) ***
Obs.	1215		124		107		167		181		118		308		210	
Number of dummy variables																
Sector	17		15		16		11		13		17		16		17	
Firm fixed effects	33		1		0		6		3		4		7		5	
Chi-square																
Cost eq.	0.963		0.986		0.989		0.987		0.994		0.969		0.943		0.965	
Wage share eq.	0.206		-0.228		0.363		-0.179		0.089		0.127		0.406		0.372	
Energy cost share eq.	0.106		-0.429		0.030		0.597		0.014		-0.165		0.086		0.379	

Note that the dependent variable is the logarithmic operating cost. The standard errors are shown in parentheses. *, ** and *** represent the 10%, 5% and 1% level significance, respectively.

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